III. General Equilibrium Linkages Between Trade and the Environment

While a great deal can be learned about the roots of environmental degradation from a sector-by-sector analysis, this approach could overlook important interactions between the different sectors and countries, so-called general equilibrium effects. It is worth taking a closer look, therefore, at general equilibrium models of international trade in order to examine the broader effects of trade on the environment in a global context. While a few such studies date back to the mid-1970s,[53] we shall concentrate here on the recent literature since the revival of the trade and environment debate, prompted by the controversial 1991 tuna-dolphin dispute between Mexico and the United States and the environmental controversies surrounding the North American Free Trade Agreement (NAFTA). Reflecting the public debate, most of the recent academic literature has focused on the environmental consequences of trade between countries with different environmental standards, which in practice means trade between developed and developing countries, since differences in environmental standards tend to reflect differences in incomes.

A. Theoretical overview

Starting with Grossman and Krueger's (1991) study on NAFTA's environmental effects, it has become customary to decompose the environmental impact of trade into three interacting elements: a composition effect, a scale effect, and a technique effect.

The *composition effect* arises from trade-induced specialization in the world. That is, countries that used to produce a wide range of products to satisfy local demand will now specialize in a subset of the product range and import the other products. This gives economic benefits through increased efficiency and economies of scale in production. The net effect on the local environment will be positive if expanding export sectors are less polluting on average than contracting import-competing sectors, and negative if the opposite relation holds.[54] Since one country's exportables are another country's importables, all countries cannot specialize in the inherently cleaner industries. International trade will therefore redistribute local pollution problems in the world from countries that have a comparative advantage in industries that are inherently less polluting to countries that have a comparative advantage in industries that are inherently more polluting, whatever the basis for these comparative advantages may be.

Second is the *scale effect*. For given pollution coefficients and a given composition of production, enhanced economic activity will increase pollution. Economic growth at given production composition and given pollution coefficients is therefore always harmful for the environment.

The silver lining of the scale effect is the associated income growth that drives the demand for a cleaner environment in the world. The willingness to pay for goods produced according to stricter environmental standards increases with income. Stricter environmental standards and taxes that reduce pollution per unit of output can thus be expected to follow rising incomes, provided of course that the political process is not captured by polluting industries or compromised by unelected governments that are not held accountable for their actions, or lack of them. The income-induced reduction in pollution per unit of output is known as the *technique effect*.

What matters for the environment is the net result of the composition, scale and technique effects, not the individual components. Decomposition is still valuable, however, since it allows us to identify what drives the results. One of the first studies to bring the bits and pieces together into a coherent trade model was that of Copeland and Taylor (1994). They present a model with two sets of countries, North (developed) and South (developing), and a range of goods with inherently different pollution intensities. The pollution problems are assumed to be of a local nature, that is, there are no transboundary or global repercussions of domestic production. Both governments are assumed to control pollution by pollution taxes, with North choosing to set higher tax rates because of higher incomes.

As trade is liberalized between North and South, a complicated set of adjustments is set in motion. The first adjustment is a change in the industrial composition, whereby polluting industries contract in North and expand in South because of different environmental standards driven by different incomes.[55] The composition effect mitigates pollution in North and magnifies it in South. In addition, there is a scale effect that emanates from an overall expansion of economic activity, which is bad for the environment everywhere. At the same time, the associated income growth brings with it an increased willingness to pay for abatement costs. Pollution taxes will be raised (the governments in the model act in the interests of the population as a whole), which in turn induce firms to take additional abatement measures to avoid the tax. The pollution per unit of output will then decline (the technique effect).

The authors show that, if the demand for environmental quality increases more than proportionally with income, it is theoretically possible that the technique effect will neutralize the scale effect. However, the technique effect will not neutralize *both* the scale effect and the negative composition effect for South, which has a comparative advantage in polluting industries due to more lax environmental standards. The conclusion is therefore that trade liberalization will mitigate local environmental prob-

53 See, e.g., Markusen (1975), Pethig (1976), Siebert (1977), and McGuire (1982).

54 In cases where some environmental indicators improve and others decline, it may be difficult to reach a verdict on the net effect.

55 Other models that take into account classical factors of comparative advantages, i.e., capital and labour abundance, generate the opposite prediction. We shall return to this point further down.

lems in developed countries (North) and magnify the problems in developing countries (South).

Another interesting result from this model, which has a bearing on trade, is that balanced growth between North and South does not increase pollution in the world. The reason is that environmental standards in North and South will then rise in tandem and thereby keep the industrial composition unchanged. Should North grow faster than South, however, emission standards will diverge further, leading to the expansion of polluting industries in South and corresponding contractions in North. This would increase overall pollution, since the average pollution per unit of output will go up. Should South grow faster than North, the opposite pattern will emerge. South's emissions standards will converge upward towards the standards of North, thereby reducing overall pollution.[56] A corollary of this finding is that trade liberalization, to the extent it adds momentum to income convergence, may help solve the world's pollution problems. Indeed, since open economies grow faster than closed economies, and since trade barriers are generally higher in developing countries than in developed countries (with some notable exceptions, including agriculture, textiles and clothing), further trade liberalization may be beneficial to the global environment.

In a companion paper, Copeland and Taylor (1995) carry out a similar exercise, with the critical difference that pollution is no longer assumed to be local but global. An example would be global warming driven by CO_2 emissions. The authors assume that emissions are limited by self-imposed national quotas implemented with nationally tradable emissions permits. As trade is liberalized between North and South, the usual composition effect arises, with clean industries expanding in North and polluting industries in South. The market price of pollution permits will then fall in North (since less polluting industries do not have as much use for them) and rise in South. The second set of adjustments is that South will find it optimal to increase the number of emissions permits to accommodate the more polluting composition of the national output. North's best response is to call in some of the emissions permits at home in order to offset the effects on the global environment. However, unless the offset is 100 per cent, which is unlikely, the trade equilibrium will involve higher emissions in the world than before trade was liberalized.[57]

A related paper by Chichilnisky (1994) takes as its starting point the observation that property rights over natural resources are often ill-defined in the South (developing countries) in comparison with the North (developed countries). Specifically, natural resources are often managed as common property systems in the South, with open (free) access. As noted in the previous section, such policies are renowned for causing overexploitation, since nobody has an individual incentive to conserve the resource. A simple model is used to show that the "tragedy of the commons" is exacerbated by trade between the North and the South. What drives the result is essentially that South has an apparent (as opposed to genuine) comparative advantage in natural resource extraction because of ill-defined property rights. South will then specialize in resource-intensive goods to a greater extent than it would have done had the property rights been well defined and natural resources managed in a sustainable way. Again, the problem is not trade per se, but weak property rights regimes and associated overexploitation of natural resources, which become even worse as demand from the world market is added to domestic demand.[58]

The results reported above are based on the critical assumption that comparative advantages in the world are determined by differences in environmental standards and resource management. These differences are in turn related to differences in per capita incomes, whereby richer countries adopt stricter environmental standards and better resource management schemes. If this were the whole story, trade liberalization would reduce environmental degradation in developed countries, exacerbate the degradation in developing countries, and increase degradation as far as global environmental problems are concerned. The moral of the story is that trade liberalization needs to be accompanied by multilateral agreements to safeguard the global environment.[59]

However, the assumption that comparative advantages are driven solely by differences in environmental standards must be questioned. Even in the world's richest country, the United States, abatement costs are only a tiny fraction of production costs, or 1 per cent on average for the US industry, rising to roughly 5 per cent for the most polluting industries (see Section IV for details). Moreover, it is the absolute difference in regulatory stringency that matters for comparative advantages not the abatement cost in any individual country. If the regulations in developing countries are, say, half as stringent, the cost disadvantage would be limited to an average of 0.5 per cent of production costs, rising to 2.5 per cent for the most polluting industries. Other factors determining comparative advantage could easily dominate such small policy-induced cost differences.

The classical explanation of comparative advantage focuses on two factors: capital and labour. Other things being equal, countries with a capital-labour ratio that exceeds the world average have a comparative advantage in capital-intensive goods, and vice versa. Since developed countries tend to be capital abundant relative to develop-

56 These results are only proven under the somewhat special assumption that the technique effect just neutralizes the scale effect.

57 In the model, global emissions will remain at the pre-trade level only if trade between North and South eliminates all income differences between them. Not even the most enthusiastic trade advocate would argue that trade alone would achieve a full convergence of incomes, although it is possible in standard trade models under certain circumstances (such as when factor endowments are not too different).

58 Brander and Taylor (1997) qualify Chichilnisky's result in a long-term version of her model. They note that countries with open access regimes will tend to run down their natural resources even in the absence of trade, and if this process has already gone far enough before trade is opened up, trade may actually give the resources a breathing space. For example, a country that has overfished its coastal waters and opens up to imports of fish may drive some of the domestic fishermen out of business, which in turn will give the fish stocks a chance to regenerate. The paper also examines the underlying reasons for overexploitation of natural resources. Apart from ill-defined property rights, a large population in relation to the resources base is a key factor in overexploitation.

59 This is one reason for why some in the environmental community would argue that it is necessary to arrest further trade liberalization until environmental safeguards are put in place.

ing countries, the former have a comparative advantage in capital-intensive production and the latter in labour-intensive production. If we review the data on the sectors that face the highest abatement costs in the United States, which presumably are also the inherently most polluting industries, they include industrial sectors such as pulp and paper, non-ferrous metals, industrial and agricultural chemicals, iron and steel, and petroleum refining. These sectors are among the most capital-intensive sectors of all[60] and will hence have a natural tendency to conglomerate in capital-abundant countries according to standard trade theory. It is questionable, indeed, if a cost disadvantage of 1 or 2 per cent because of higher pollution-abatement costs in developed countries will turn comparative advantages 180 degrees around.

If the classical pattern of comparative advantage prevails, that is, is not reversed because of 1 or 2 per cent higher pollution-abatement costs, the previous results are turned on their head. As shown by Antweiler, Copeland, and Taylor (1998), trade between developed and developing countries will then rather increase pollution in developed countries (because of increased specialization in capital-intensive production), reduce pollution in developing countries (because of increased specialization in labour-intensive production), and reduce pollution overall in the world (because a large share of the polluting production will take place in developed countries with stricter environmental regulations).

To summarize, the above theoretical review has demonstrated that there is no simple one-to-one relationship between trade and the environment, and that the results are often sensitive to the assumptions adopted by individual models. The most robust result is that trade will mitigate local pollution problems in countries with a comparative advantage in industries that tend to be inherently cleaner and magnify local pollution problems elsewhere. This result is almost definitional. As trade is liberalized, global pollution problems will get worse *if* differences in environmental standards dominate classical factors of comparative advantage (capital abundance for developed countries and labour abundance for developing countries), and improve *if* classical factors of comparative advantage dominate differential environmental standards. We have argued that the second case is likely to hold sway because of the relatively tiny share of production costs that is attributable to pollution abatement. Ultimately, however, this is an empirical question.

Let us also stress that general equilibrium models of trade and environment are still in their infancy. The field started just a few years ago. It is possible that future models that account for other factors of production shaping comparative advantages, such as natural resources or the distinction between skilled and non-skilled labour, may arrive at a different set of conclusions. Thus, in wait for more elaborate theoretical models, we should be somewhat cautious in our conclusions.

B. Empirical overview

Turning now to the empirical side, let us start with the issue of whether differences in environmental standards can reverse the classical pattern of comparative advantage. Such tendencies would presumably be reflected in global trade patterns. As will be shown, very little evidence points in this direction.

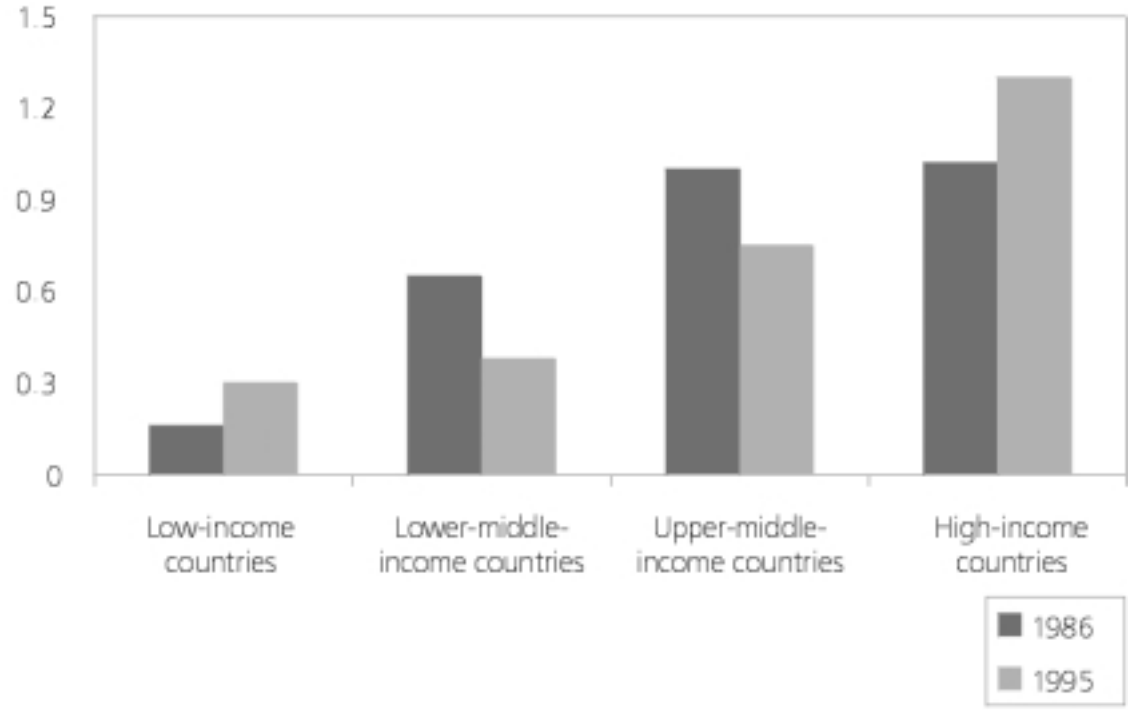
Tobey (1990) finds no evidence to suggest that differential environmental standards affect global trade patterns to any significant degree. Rather, trade patterns were found to be determined by standard factors of comparative advantages, such as capital, labour and natural resource endowments. Likewise, reviewing changes in international trade between 1970 and 1990, Sorsa (1994) finds that industrialized countries' share of manufacturing exports in the world has declined from 91 per cent to 81 per cent. However, most of this decline was recorded in labour-intensive sectors such as textiles, apparel, footwear and other light manufacturing, in which the comparative advantages have drifted to developing countries with lower labour costs. In contrast, developed countries' share of world trade in "environmentally sensitive sectors" (the politically correct terminology nowadays for goods produced by polluting industries), which are by nature relatively capital intensive, remained essentially unchanged (81.1 per cent in 1990 compared to 81.3 per cent in 1970). Likewise, Xu (1998) found no evidence that developing countries have gained a comparative advantage in polluting industries over the period 1965 to 1995.

The evidence presented by Low and Yeats (1992) seems, at least at first sight, to suggest otherwise. They analyze the secular development of the pollution-intensity of trade in developed and developing countries between 1965 and 1988, a period in which environmental standards were gradually upgraded in developed countries. Polluting industries are identified as those incurring the highest level of pollution abatement and control expenditures in the United States, including chemicals, nonferrous metals, iron and steel, pulp and paper, petroleum products, and other raw-material processing. The study found that developing countries had increased their share of world trade in these industries from some 22 to 26 per cent, with a rising share of pollution-intensive exports in Eastern Europe, Latin America and Western Asia, and a falling share (since the mid-1980s) in South-East Asia. These figures suggest that comparative advantages in pollution-intensive production drifted somewhat towards developing countries during this period, although the authors are not able to pin down the role of environmental standards in this process. As they note, many of the polluting industries are those associated with the early stages of industrialization. And this industrialization would presumably have come about even without a cost advantage of 1 or 2 per cent over industrialized countries because of more lax environmental standards.

In any case, the tendency reported in Low and Yeats seems to have been reversed in the 1990s, according to the World Bank (1998). Chapter 3 of *World Development Indicators* presents data on net exports of pollution-inten-

60 According to Repetto (1995), "petroleum refining, chemicals manufacturing, pulp and paper, and primary metals—the environmentally sensitive industries in which pollution abatement costs represent a relative large fraction of output value—are all among the industries with the fewest employees per million dollars in shipment." (p. 22.)

Figure 6: Export-import ratio in pollution-intensive goods



Source: Reproduced from Figure 3b, World Bank (1998).

sive goods for different countries for 1986 and 1995 respectively. The results (Figure 3b, p. 113) are reproduced above. Contrary to the common perception, the results show that developing countries, with a few exceptions, do not specialize in highly polluting industries. Rather, they import more pollution-intensive goods than they export (the export-import ratio is less than one in these industries), while the opposite is true for developed countries. In addition, developed countries have strengthened their comparative advantages in polluting industries over the last decade, in spite of stricter environmental standards, as becomes evident when comparing the 1986 and 1995 data. As concluded in the World Bank report, pollution-intensive production increasingly takes place in countries with relatively stringent environmental regulations.

In summary, evidence based on the pollution-intensity of trade does not seem to support the perception that developing countries are gaining a comparative advantage in pollution-intensive production because of lax environmental regulations. The tendency, at least in the last decade, is rather that developed countries are strengthening their position in polluting industries, which suggests that classical factors of comparative advantages predominate over differential environmental standards. This is not surprising, since polluting industries tend to be very capital intensive, and since abatement costs, even in countries with the most stringent regulations, represent only a small percentage of production costs.

As explained earlier, if classical factors of comparative advantages predominate over differential environmental standards, as they seem to do, further trade liberalization will reduce average pollution per unit of output in the world because of a benign composition effect. In other words, trade liberalization will shift more pollution-intensive production to developed countries and thereby bring down the emissions per unit of output because of stricter regulations. However, total emissions may still increase if the scale effect overrides the technique effect, that is, if production expands faster than the reduction in the pollution per unit of output.

The study by Antweiler, Copeland, and Taylor (1998) referred to earlier suggests that total emissions could fall. The empirical evidence is based on the relationship between trade and ground level SO_2 concentration. The data cover 44 countries over the period 1971 to 1996. Decomposing the impact of trade into the usual composition, scale and technique effects, they found evidence that trade changes the composition of national output in a more polluting way for capital-abundant countries. This suggests that classical factors of comparative advantages are important, but *also* for the poorest countries, in which lax environmental regulations may have had an influence. In other words, SO_2-intensive production seems to be migrating from middle-income countries to both richer and poorer countries,[61] leaving the net composition effect on the environment undetermined. At the same time, the technique effect seems to dominate the scale effect. The authors find that, other things being equal, a 1 per cent increase in the scale of economic activity raises SO_2 concentration by 0.3 per cent, while the technique effect ac-

61 Note that this finding is consistent with Figure 6.

Table 4: The impact of the Uruguay Round on air pollution (percentage change)

	NO_2		SO_2		CO		SPM		$C0_2$	
	Comp. effect	Net effect	Comp. effect	Net effect	Comp. effect	Net effect	Comp. effect	Net effect	Comp. effect	Net effect
EU	0.1	0.2	0.3	-0.4	0.2	-0.3.	0.2	-0.3	..	0.4
USA	0.1	0.1	0.4	-0.7	0.1	-0.6	0.2	-0.8	..	0.3
Japan	0.3	0.1	2.0	2.0	0.3	-1.0	0.3	-0.5	..	0.4
China	-0.3	1.6	-1.8	2.1	-0.1	1.8	-0.9	2.0	..	1.4
East Asia	-0.1	2.0	-3.1	1.8	-1.9	1.9	-3.0	1.7	..	1.7
South Asia	-0.5	1.0	-0.6	1.3	-0.5	1.3	-0.4	1.4	..	1.7
Africa	0.2	2.0	-0.1	2.8	-0.1	2.4	0.0	2.7	..	1.8
Latin America	0.6	0.9	0.5	0.7	0.2	0.8	0.4	0.6	..	1.0
Eastern Europe	0.2	0.1	-0.1	0.0	0.1	0.2	0.1	0.0	..	0.1
Global	0.04	0.5	-0.3	0.2	-0.05	0.1	-0.1	0.1	..	0.5

companying higher incomes reduces pollution by 1.4 per cent, resulting in a net reduction of 1.1 per cent. For the average country, increased trade may therefore reduce SO_2 emissions, although capital-abundant and poor countries may see increased emissions as they absorb a larger share of air-polluting industries.

C. Applied models

Let us end this section by reviewing some applied models that try to simulate the environmental effects of trade liberalization. There exist off-the-shelf computable general equilibrium models of the world economy in which countries are linked through trade flows. The most notable efforts in this direction are the models developed by the Global Trade Analysis Project (GTAP), a consortium of national and international agencies based at Purdue University.[62] One problem with using these models for environmental assessments is the lack of industry-specific pollution data (pollution per unit of output) on a country-by-country basis. If such data were available, one could first simulate changes in production and consumption patterns that take place as trade is liberalized and then use these results to calculate the associated changes in pollution. Such an exercise would capture the composition and scale effects of trade but not income-induced changes in pollution coefficients. To account also for the technique effect, one would need to know how different governments respond to income growth in terms of upgrading their environmental standards. In short, while feasible in theory, data problems have prevented fully satisfactory applied analyses of how trade liberalization affects the environment. Nevertheless, there have been some initial attempts that are worth reporting.

Cole, Rayner, and Bates (1998) estimate the impact of the Uruguay Round on five air pollutants; nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), suspended particulate matter (SPM), and carbon dioxide (CO_2). They start with the results of Francois, McDonald, and Nordström (1996) on the changes in production in various sectors and regions as a result of the Uruguay Round. They then combine these results with estimates of the pollution intensity of various sectors in the United States. Since they do not have sectoral pollution data for other countries, they use the US coefficients scaled upward or downward to make the total emissions consistent with the data. Finally, to account for the income-driven technique effect, they estimate the average relationship between per capita income and per capita emissions in the world, i.e., the environmental Kuznets curve (see Section V). The results are reproduced in Table 4, which shows the estimated changes in the emissions of the various air pollutants attributed to the Uruguay Round.

As far as the composition effect is concerned, the Uruguay Round is found to shift the composition of national output towards more air-pollution-intensive manufacturing in developed countries (the European Union, United States, and Japan) and in the other direction in developing countries (with the exception of Latin America). This is a reflection of developed countries' comparative advantage in capital-intensive production. However, in

62 This model was used by the WTO Secretariat in evaluating the economic effects of the Uruguay Round. For more information on the GTAP model and applications of this model, see the GTAP Website: www.agecon.purdue.edu/gtap.

spite of the composition effect, some air pollutants are projected to go down.[63] The reason for this is that the income-induced technique effect dominates both the scale and composition effects. The reverse is true for Asian developing countries, in which air pollution is projected to increase. This is because of the rapid expansion of economic activity, which is not moderated to the same extent as in developed countries by a positive technique effect (driven by stricter emissions regulations). In turn, this is a result of the non-linear relationship between income and pollution (see Section V for details). As far as developing countries in Africa, Latin America and Eastern Europe are concerned, air pollution is projected to go up, because of both a generally negative composition effect and a scale effect that is not completely counterbalanced by the technique effect. Finally, note that NO_2 emissions are projected to increase in all countries. The reason for this is that the turning point of the EKC (the per capita income level at which pollution starts to decrease) is much higher for NO_2 than for SO_2, SPM, and CO, respectively. Likewise, CO_2 emissions are projected to increase everywhere for the same reason (an even higher turning point).[64]

The projected increase in air pollution attributed to the Uruguay Round is estimated at between 0.1 and 0.5 per cent of base emissions. These increases should be weighted against the estimated income gain of between $200 to $500 billion. If the political will existed, a small fraction of this gain (a few percentage points according to the study) would suffice to pay for the additional abatement costs to redress the environmental impact.

Lee and Roland-Holst (1997) further demonstrate the point that income gains of trade could in principle pay for the additional abatement efforts to negate any repercussions on the environment, and still leave a positive economic benefit. Their case study is a three-region simulation model, comprising of Indonesia, Japan and the rest of the world. The base case is a unilateral removal of all trade barriers in Indonesia. This would lead to a profound structural change in Indonesia's industrial composition. Polluting and resource degradation sectors such as petroleum, lumber, mining, chemicals, and non-ferrous metals would expand, whereas other sectors that are less polluting would contract. At the same time, if trade liberalization is combined with stricter environmental regulations, the authors show that the harm to the environment can be undone and still give a net economic surplus.

One problem of environmental assessments of trade liberalization is the lack of environmental data for developing countries. A promising approach to overcome this problem is due to Dessus, Roland-Holst and van der Mensbrugghe (1994). On the basis of US data, they estimate that some 90 per cent of toxic emissions can be explained by less than 10 inputs, including fossil fuel, ferrous and non-ferrous ores, fertilizers, and various chemicals. Environmental appraisals of trade reforms can then be undertaken on the basis of simulated changes in the use of polluting intermediate inputs for which data is more readily available than emissions data.

The authors used this approach to study trade policy reforms in Mexico and, more recently, Chile.[65] For the first exercise, they based their analysis on a large-scale computable general equilibrium model of the Mexican economy.[66] The model assumes that there is some substitutability between different inputs. Another important element of the model is the vintage structure of capital. That is, new capital that becomes available as the economy grows and older capital depreciates offers greater substitutability between different inputs than current vintages that are designed for certain input composition. On the basis of these key assumptions, the authors simulate structural changes in the Mexican economy arising from labour growth and investments for given trade barriers over the period 1990 to 2010. They then use this base scenario to evaluate the environmental effects of NAFTA. The effects turn out to be relatively minor. The composition of the Mexican economy changes slightly towards more labour-intensive goods that use less polluting inputs. At the same time, because of the increased scale of economic activity, including expansion of some polluting sectors, such as oil, coal, and gas, the overall effect on the environment is negative for most categories of pollutants. The authors also simulate the effects of combining NAFTA with environmental reforms to speed up the substitution towards cleaner inputs. The experiment can be thought of as capturing the effects of the environmental side-agreement to NAFTA. The finding is encouraging—the environmental effects of increased trade can be negated without giving up much of the income gain, provided that governments use efficient (market-based) policies to combat environmental degradation.

D. Concluding remarks

Numerical models have confirmed the theoretical results that trade liberalization can harm the local environment in countries with a comparative advantage in polluting industries and improve the local environment elsewhere. At the same time, the simulations indicate that the income gains of trade could, in principle, pay for additional abatement costs in order to undo any negative repercussions on the environment and still leave a net surplus. In other words, by combining trade and environmental reforms one should be able to find ways to raise incomes without compromising the natural environment. In this sense, at least, there is no inherent conflict between trade and the environment. Rather, the conflict arises as a result of the failure of political institutions to address environmental problems, especially those of a global nature which require a concerted effort to solve. Of course, political shortcomings may in turn be related to the globalization of the world economy, which has made capital more mobile and hence more difficult to regulate for individual countries. This line of argument will be investigated in detail in the next section.

63 Note that the net effect for S02, CO, and SPM emissions is in the negative in the European Union, United States, and Japan.

64 If the Kyoto Agreement is successful, emissions will not grow as much as suggested in this exercise for developed countries. However, it is unclear whether this would reduce total emissions of CO2 because of the lack of commitment from developing countries.65 Beghin, Roland-Holst, and van der Mensbrugghe (1994) and Beghin, Bowland, Dessus, Roland-Holst, and van der Mensbrugghe (1998), respectively.

65 Beghin, Roland-Holst, and van der Mensbrugghe (1994) and Beghin, Bowland, Dessus, Roland-Holst, and van der Mensbrugghe (1998), respectively.

66 The name of the model is TEQUILA: Trade and Environment eQUILIbrium Analysis.

IV. Does Economic Integration Undermine Environmental Policies?

As observed by Levinson (1996a), "[F]or nearly a quarter century, since industrialized nations began legislating and enforcing environmental laws with substantial compliance costs, critics of those regulations have protested that stringent environmental regulations force manufacturers of pollution-intensive products overseas. Jargon such as 'eco-dumping', 'race to the bottom', and 'competition in laxity' has been used to describe a feared consequence of this phenomenon, that different jurisdictions competing to attract international businesses would create pollution havens by lowering their environmental standards below socially efficient levels." (p. 429)

The race-to-the-bottom hypothesis was initially developed in the context of local competition for investments and jobs within federal states with decentralized responsibilities for the environment. A case in point is the United States.[67] Before 1970, individual states were free to define their own standards as they saw fit. In principle, this should produce a desirable diversity of standards tailored to local conditions and willingness to pay for environmental amenities. What was right for California was not necessarily right for North Dakota, and so on, because of the huge differences in climate, ecological conditions, population density, and per capita incomes. There were essentially two reasons why the decentralized regime came under pressure. The first was the failure of the system to account for interjurisdictional pollution problems, i.e., pollution spilling over from one state to another. The second was the inability of governments to regulate mobile industries that could defeat the measures by relocating elsewhere in the country.[68] In fact, very little progress was made, and under growing pressure from the awakening environmental opinion, the US Congress concluded that a federal initiative was necessary to break the foot-dragging at the state and local levels. Starting in 1969, a series of laws was passed—among them the National Environmental Protection Act (1969), the Clean Air Act (1970), the Clean Water Act (1972) and the Endangered Species Act (1973)—which gradually shifted the initiative and regulatory authority from the local level to the federal level.

The very same arguments can and have been made with increasing frequency at the supranational level. Indeed, many pollution problems transcend national borders and some are truly global in scope, such as depletion of the ozone layer and global warming. Moreover, while capital was more mobile within countries in the past, and hence more susceptible to domestic variations in environmental standards, international mobility is gradually increasing. The average growth rate of foreign direct investment (FDI) in recent decades has been 12.5 per cent a year, roughly twice as fast as growth in world merchandise trade and five times faster than growth in world GDP.[69] The tremendous growth in FDI has been underpinned by the removal of investment barriers, especially since the mid-1980s. Virtually all developing countries today are open to FDI, and increasingly also the least-developed countries. The investment regimes of OECD countries were largely liberalized already in the 1950s and 1960s. The roll-back of investment barriers, in combination with reduced trade barriers, has increased the location options for multinational firms, which in turn has reduced, or at least, is *perceived* to have reduced the environmental policy autonomy of individual nations.

While international competition for investments and jobs can play out in many ways,[70] the particular concern of environmentalists is that governments will sell out their environment rather than offering, say, a tax break. Indeed, some evidence suggests that new regulations are occasionally defeated in the political arena on the grounds that they would harm national competitiveness.[71] Such defeats are fomented by the perception in industrialized countries that environmental regulations are costing domestic investment and jobs. For example, an astounding one third of the respondents to a 1990 poll by the Wall Street Journal thought it was somewhat or very likely that their own jobs were threatened by environmental regulations, compared to actual data that suggest that less than 0.1 per cent of the lay-offs (that is, one in a thousand) in the United States between 1987 and 1990 were related to stricter regulations.[72] Given such public perceptions, or misperceptions as they seem to be, governments may find it exceedingly difficult to upgrade environmental standards in the face of vocal criticism from affected industries and workers.

A competitiveness-driven "regulatory chill" may not just slow down the environmental agenda, but also the trade agenda. For example, NAFTA was opposed by the environmental community, who argued that it would lead to mounting pressure to reduce US and Canadian environmental standards to Mexican levels to keep investments and jobs at home. These concerns were echoed by the trade unions and their allies, notably the leader of the Reform Party of the United States, Ross Perot, who captured people's imagination by using the image of a "giant sucking sound" of jobs migrating south of the Rio Grande. Similar concerns were raised about the Multilateral Investment Agreement (MAI) negotiated under the auspices of the OECD. Opposition to the MAI was voiced on the grounds that it would give multinational firms too

67 Peltzman and Tideman (1972), Swire (1996) and Esty (1996).

68 Levinson (1996a) cites the following statement of Louisiana Governor Edwin Edwards to illustrate this point: "We did what we thought was best for the people and the economy of Louisiana. We accommodated industry where we thought we could in order to get the jobs and the development, and in some instances knowingly and advisedly accepted environmental trade-offs." (p. 443.)

69 See WTO (1998a), Annex C.

70 See UNCTAD (1996).

71 See Esty and Geradin (1998) for some recent examples.

72 See Goodstein (1995).

much leverage over host governments, a leverage that could potentially be used to challenge new environmental taxes and regulations.

Given the importance of these arguments both from a trade and an environmental perspective, it is worth reviewing carefully the evidence relating to this matter. Is it true, as many seem to believe, that stringent environmental regulations undermine the competitiveness of domestic industries? Do polluting industries relocate from developed to developing countries in order to take advantage of lax regulations? Are environmental standards bid down in accordance with the race-to-the-bottom hypothesis? Or, if not, has the globalization of the world economy been followed by increased political reluctance to address environmental problems as suggested by the regulatory chill hypothesis?

A. The competitive consequences of environmental regulations

Comparison of compliance costs with different national environmental regulations is seriously hampered by lack of data. Only the United States has regularly published data on compliance costs based on an annual survey of US industry. This survey was discontinued for budgetary reasons in the mid-1990s, however. Nor are we aware of any indexes that allow comparisons of the stringency of environmental regulations in different countries, except for an index produced by UNCTAD in the mid-1970s with doubtful relevance today.[73]

The US data, although a few years old, can at least give us an idea of the abatement costs incurred by various industries, and hence the potential cost savings of moving production offshore to a country with lower standards. As detailed in Table 5, based on the pollution-abatement costs and expenditures report of the Census Bureau (1996), the average industry in the United States spent some 0.6 per cent of its revenue (value of shipment) on pollution abatement, rising to between 1.5 and 2 per cent for the most polluting industries—petroleum and coal products, chemicals and allied products, primary metal industries, and paper and allied products.

While these figures may not seem that high, it should be stressed that the data refer to industry averages on the 2-digit Standard Industrial Classification (SIC) level, and that the pollution abatement cost (PAC) may be higher for certain industries within each industrial classification category. For example, an earlier compilation by Low (1992) at the 3-digit level found PAC of up to 3.2 per cent of the value of shipment. The extent to which these estimates apply to other OECD counties is unclear. However, according to an OECD (1997) study, "direct environmental costs are *believed* (emphasis added) to account for 1-5 per cent of production costs." (p. 7)[74]

While additional costs of 1 to 5 per cent could be high for an industry that is subject to stiff international competition, some observers have argued that the numbers look worse than they are. This argument is foremost associated with Professor Michael Porter of the Harvard Business School—the "Porter hypothesis".[75] The argument is essentially that regulatory pressure just like competitive pressure encourages industrial innovations that often result in new commercially valuable products or industrial processes. One example is DuPont's strategy to be in the forefront of the development of substitute products for ozone-depleting CFCs, which has apparently given the company an advantage in the international competition.[76] Another example can be attributed to US Vice President Albert Gore (1992), cited in Palmer et al. (1995, p. 342), who writes that "3M, in its Pollution Prevention Pays program, has reported significant profit improvement as a direct result of its increased attention to shutting off all the causes of pollution it could find."

The Porter hypothesis has been the subject of a great deal of empirical research. For example, Jaffe and Palmer (1997) examine the statistical relationship between pollution-control expenditures and innovative activity across US industries. The authors find that pollution-abatement expenditures do trigger additional R&D, but seemingly of a limited commercial value beyond helping firms comply with the regulations. Morgenstern et al. (1997) estimate the change in production costs associated with a change in reported pollution-control expenditures. Their preferred statistical specification suggests that an incremental dollar spent on pollution control is associated with 13 cents increase in production costs for the average industry, with a standard deviation of 69 cents. Berman and Bui (1998) examine the effects of US air-quality regulations on the productivity of oil refineries from 1977 to 1993, a period marked by a gradual tightening of standards. They found that oil refineries located in areas with stringent regulations, such as southern California, recorded faster productivity growth than oil refineries operating under less stringent regulations, presumably because the former were forced to advance their investment plans in new technologies.

Cohen and Fenn (1997) examine whether good environmental performance harms or helps a company's bottom line. The study is based on financial and environmental data of all 500 companies included in the Standard and Poors (S&P) index, divided into 85 industries. The authors compare the performance of two investment portfolios: one "green" portfolio, including only the environmental leaders in each industry (those with an environmental record better than the median of the industry), and one "brown" portfolio including only the environmental laggards. To check that the results are robust to different environmental and financial performance measures, they make a total of 54 portfolio comparisons on the basis of different combinations of nine environmental performance measures, three financial performance measures, and three time periods. In 80 per cent of the comparisons, the "green" portfolio outperformed the "brown" portfolio fi-

73 See Tobey (1990).

74 Note that the OECD study refers to PAC as a percentage of *production costs*, whereas the Bureau of Census data, reported in Table 5, refers to PAC as a percentage of the *value of shipment*. The two concepts are closely related, however, since market prices (the value of shipment) in the long run tend to be competed down to the unit production costs, including a "normal" return to capital.

75 See Porter (1991) and Porter and Van der Linde (1995).

76 See Porter (1991).

Table 5: Pollution abatement operating costs by US industry (1993):

SIC	Industry	Pollution abatement operating costs (million US$)	Value of shipment (million US$)	Abatement cost/ value of shipment (%)
29	Petroleum and coal products	2'793	144'715	1.93
28	Chemicals and allied products	4'802	314'744	1.53
33	Primary metal industries	2'144	142'384	1.51
26	Paper and allied products	1'948	133'486	1.46
32	Stone, clay and glass products	544	65'574	0.83
31	Leather and leather products	52	9'991	0.52
34	Fabricated metal products	742	175'137	0.42
22	Textile mills products	280	73'951	0.38
30	Rubber and miscellaneous plastic products	409	122'776	0.33
20	Food and kindred products	1'368	423'257	0.32
37	Transportation equipment	1'327	414'614	0.32
36	Electronic and other electric equipment	716	233'342	0.31
24	Lumber and wood products	279	94'547	0.30
25	Furniture and fixtures	137	47'349	0.29
38	Instruments and related products	383	136'916	0.28
39	Miscellaneous manufacturing industries	85	42'426	0.20
35	Industry machinery and equipment	488	277'957	0.18
27	Printing and publishing	266	172'737	0.15
21	Tobacco products	33	28'384	0.12
	Average of all industries	18'796	3'054'287	0.62

Note: Pollution abatement operating costs include capital depreciation of the abatement equipment; filters and another material, salaries and wages for operational personnel, etc.

nancially, although the differences were only statistically significant in 20 per cent of the cases. While the result is not strong enough to give unambiguous support to the Porter hypothesis, the authors conclude that there is at least no systematic evidence that a good environmental performance comes at the expense of reduced profitability. Repetto (1995) reaches the same conclusion using a similar methodology. Pairing data on the financial and environmental performance of thousands of large manufacturing plants in the United States, he concludes that "there is no overall tendency for plants with superior environmental performance to be less profitable."

While the evidence seems to be rather supportive of the Porter hypothesis, some leading environmental economists, including Palmer, Oates, and Portney (1995), caution us against drawing too-far-reaching conclusions. They agree with Porter that early estimates of the regulatory compliance costs may have been biased upward because of unforeseen technological advances in pollution control or because of the discovery of cost-saving or quality-improving innovations. They also point out that recent surveys of pollution-control expenditures carried out by the Census Bureau have tried to account for such "offsets" and find that they are quite small, in fact just a few percentage points of the overall costs of pollution control. Moreover, when interviewing the companies referred to by Porter and his colleagues, a somewhat less optimistic picture emerges. Palmer et al. write, "while each manager acknowledged that in certain instances a particular regulatory requirement may have cost less than had been expected, or perhaps even paid for itself, each also said quite emphatically that, on the whole, environmental regulation amounted to a significant *net* cost to his company." (p. 127) In other words, we should not have any illusion that environmental regulations will cost nothing.

They do cost, but they also bring significant benefits to society and to the quality of life.

In summary, competitiveness concerns seem to have been somewhat overstated in the public debate.[77] Abatement costs in the United States, while perhaps higher than in most other countries, still only account for a few percentage points of the production costs. That is, the overwhelming share of production costs, and hence any competitiveness problem, is determined by other factors, such as wages, payroll taxes, capital costs, import tariffs on intermediate inputs, corporate taxes, and so on.[78] Of course, this is not an argument for ignoring concerns about pollution-abatement costs. On the contrary, if the costs can be reduced without compromising the environmental objective by employing modern market-based instruments instead of traditional command-and-control regulations, so much the better.[79] A natural objective for regulators, one would imagine, is to minimize the costs of achieving the environmental targets defined by society. The reason why the Porter hypothesis may hold for some industries but not for others could simply be that some industries are regulated in a more efficient manner than others.[80] Finally, and perhaps most importantly, while the debate is on costs, studies that focus on the profitability of firms have not been able to detect that superior environmental performance comes at the expense of reduced profitability. One reason, which we shall return to later, is that a good environmental profile can be a valuable market asset that allows firms to recoup pollution-abatement expenditures in the market place.

B. Do environmental regulations induce the relocation of firms?

Another way of assessing the competitive consequences of environmental regulations is to study whether the regulations affect an industry's location decision. Again, such studies are hampered by the lack of data on the regulatory stringency in various countries. Before we investigate the meagre international evidence, let us begin with a review of the US experience, which is documented in many empirical studies, especially on the location effects of federal air quality standards.[81]

Air quality standards in the United States are regulated by the Clean Air Act of 1970 and subsequent amendments. Under the 1977 amendment, each county is officially classified as being either in or out of attainment, which in turn determines the regulatory stringency that applies to that county. According to Becker and Henderson (1997), the strictest pollution-abatement requirements apply, in descending order, to: (1) new plants in non-attainment areas; (2) existing plants in non-attainment areas, because of "grandfather" rights that allow greater emissions; (3) new and existing *big* plants in attainment areas, because larger plants are subject to closer scrutiny by the EPA; and (4) new and existing *small* plants in attainment areas. Overall, regulation and enforcement activities confer a regulatory advantage to plants located in attainment areas over non-attainment areas, to smaller plants over bigger plants, and to older plants over newer ones. If these differences are important, we should expect the following pattern to emerge in the data: (i) the birth of new polluting plants should be higher in attainment areas than in non-attainment areas; (ii) the size composition should shift from bigger to smaller plants; and (iii) the survival rate of older plants with grandfather rights should increase. In fact, all of these theoretical predictions *are* confirmed by Becker and Henderson in their unique data tracking individual plants in four polluting industries (organic chemicals, plastic products, metal containers, and wood furniture) from 1967 to 1992.

Henderson (1996) provides further evidence to that effect. He finds a significant reduction of polluting plants in counties that had switched into non-attainment status, and a significant increase in polluting plants in counties with a three-year record of attainment. As observed by Henderson, while the average air quality in the United States has improved very noticeably as a result of the national standards, part of the effect has been achieved through relocation of polluting plants from more polluted to less polluted areas, and not just (as perhaps was the intention) through an upgrading of pollution controls in general, and in non-attainment areas in particular. Kahn (1997) also corroborates this observation. Combining county data on air quality with manufacturing data, he estimates each industry's contribution to air pollution. Comparing estimates for different years, he finds that emissions per unit of manufacturing output have declined steadily over time, suggesting a positive impact of the national air quality standards. At the same time, part of the air quality improvements in polluted areas has been achieved by a relocation of polluting industries. Specifically, for the case of the US "rust belt", half of the improvement in air quality between 1977 and 1987 was attributable to a decline in polluting industrial activities that moved elsewhere.

While these studies seem to provide strong evidence of a relocation effect of environmental regulations, and hence that they do in fact matter for an industry's com-

77 The same conclusion was drawn in two more comprehensive surveys by Jaffe et al. (1995) and Levinson (1996a), respectively. Jaffe et al. conclude: "Overall, there is relatively little evidence to support the hypothesis that environmental regulations have had a largely adverse effect on competitiveness, however that elusive term is defined." (p. 157.) Likewise, Levinson concludes: "Whatever the reason, there remains a large gap between the popular perception that environmental regulations harm competitiveness and the lack of evidence to support this perception." (p. 453.)

78 To give one example, the production costs of steel in the United States are estimated at $513 per tonne, of which $15 can be attributed to pollution abatement. The cost of producing steel in Mexico is estimated at $415 per tonne. Thus, even if all environmental regulations were to be removed in the United States, the production costs would still exceed the Mexican level by $83. That is, whatever the roots of the competitiveness problems of the US steel industry, only a tiny fraction can be blamed on environmental regulations. OECD (1997).

79 For example, Palmer et al. (1995) report that tradable permits for SO2 emissions are estimated to reduce the costs of the 1990 acid rain control programme by at least 50 per cent, when measured against the most likely command-and-control alternative. Given the huge potential cost savings, regulators have to assume *their* share of any competitiveness problems that may arise because of a reluctance to give up old-fashioned command-and-control regulations for modern market-based instruments.

80 See Repetto (1995), Section VI, for a useful discussion on this point.

81 The review is limited to the more recent evidence. For a comprehensive survey, including also older studies, see, e.g., Levinson (1996a) and Jaffe et al. (1995).

Table 6: Surveys of the importance of environmental regulations to plant locations in the United States

Survey	Sample	Result
Epping (1986)	Survey of manufactures (late 1970) that located facilities 1958-1977	"Favourable pollution laws" ranked 43rd to 47th, out of 84 location factors presented.
Schmenner (1982)	*Fortune* 500 branch plants opening 1972-78	Environmental concerns not among the top 6 items mentioned.
Fortune (1977)	*Fortune's* 1977 survey of 1,000 largest U.S. corporations	11% ranked state or local environmental regulations among the top 5 factors.
Wintner (1982)	68 urban manufacturing firms	29 (43%) mentioned environmental and pollution control regulations as a factor in location choice.
Stafford (1985)	162 branch plants built in the late 1970s and early 1980s	Environmental regulations were not a major factor, but more important than in the 1970s. When only self-described "less clean" plants were examined, environmental regulations were of "mid-level importance."
Lyne (1990)	*Site Selection* magazine's 1990 survey of corporate real estate executives	Asked to pick 3 of 12 factors affectong location choice, 42% included "state clean air legislation."
Alexander Grant and Company (various years)	Survey of industry associations	Environmental compliance cost given an average of 4%, though growing slightly over time.

Source: Reproduced from Table 3 in Levinson (1996).

petitiveness, a study by Gray (1997) cautions us that other factors might be inducing firms to move. Like others, Gray finds a significant negative correlation between plant birth rates and measures of regulatory stringency. However, contrary to what one *should* expect to find, there is no significant difference between the impact on highly polluting industries and industries in general. That is, clean industries shun non-attainment counties at the same rate as polluting industries, which suggests that there is something else about non-attainment areas that makes them less attractive to invest in. For example, polluted areas may not be particularly nice to live in, so when the population and purchasing power decline in those areas, industries may follow in the tracks of the people (workers) rather than vice versa.

Further doubt is cast by survey evidence (see Table 6) in which managers were asked to rank factors of importance for their location decisions, including environmental compliance costs. The general impression from these surveys, whatever their worth, is that environmental regulations are only of marginal importance, with the possible exception of self-declared "less clean" industries that tend to give environmental compliance costs a higher weighting in their location decisions.

In summary, the US experience suggests that compliance costs could have an impact on the location of polluting plants. However, there are some remaining questions that need to be addressed before making a definite assessment. As Gray (1997) points out, not only do polluting industries shun polluted areas with stricter regulations, but so do all kinds of businesses, including clean industries that are not directly affected by such regulations. This suggests that other factors are involved in a firm's location choice, including perhaps even the pollution itself. That is, industries may want to be located where the markets are, and polluted areas may represent shrinking markets. The intriguing policy conclusion would then be that strict environmental regulations, by attracting people that want to live in an unspoiled environment, may indirectly attract industries rather than driving them away.

C. International evidence

Turning now to the international dimension of the issue, do polluting industries migrate from countries with high environmental standards to those with low standards? Some indirect evidence with bearing on this issue has already been reported in Section III. Specifically, studies of trade patterns have not found much evidence that developing countries have taken over the dirty end of production.

Of course, trade data can only provide indirect evidence on the issue. However, studies on FDI flows do not seem to give a different answer. For example, analyzing

outward investment from the United States in 1992, Repetto (1995) noted that although developing and transitional economies received 45 per cent of outward FDI from the United States, their share of environmentally sensitive industries (petroleum and gas, chemicals and related problems, and primary or fabricated metals) is considerably smaller. Only 5 per cent of the investments received by developing and transitional economies went into these sectors, compared with 24 per cent of the investments received by developed countries. He concludes that, "to the extent that the developed countries are exporting their dirty industries, they seem to be exporting them to each other, not to the less developed economies." (p. 8)

This conclusion is corroborated by Albrecht (1998), who asks whether the outflow of FDI from the United States is concentrated in dirty industries and the inflow concentrated in clean industries. In fact, it is just the opposite. Outward FDI is growing faster in clean industries, while inward FDI is growing faster in dirty industries. In other words, the United States seems to be "importing" more dirty industries than it is "exporting". Likewise, Eskeland and Harrison (1997) investigates whether inward FDI in developing countries is concentrated in polluting industries. The study covers investments into Mexico, Venezuela, Côte d'Ivoire and Morocco during the 1980s, with the first two countries receiving most of their investments from the United States and the other two from France. No evidence was found to suggest that investments in these countries were biased towards polluting sectors. The authors cross-checked these findings by estimating the impact of pollution-abatement costs on outward FDI from the United States more generally. The found that US industries that face high pollution-abatement costs at home are no more likely to invest abroad than US industries on average.

There are some studies that reach the opposite conclusion, however. For example, Xing and Kolstad (1998) found some evidence that the location of the US chemical industry was affected by the laxity of the host country's environmental regulations, as approximated by the economy-wide SO_2 emissions,[82] while other less polluting industries were not. The estimated impact was relatively small, however. If a host country allows SO_2 emissions to be increased by 1 per cent, it may be able to attract $0.27 million of additional investment from the US chemical industry. For comparison, the total annual FDI by the US chemical industry is $4 billion. Bouman (1996) reached a similar conclusion while studying outward investments from Germany. Thus, we shouldn't rule out the possibility that environmental regulations could have an impact on foreign investment decisions at the margin, at least for the most polluting industries. The point is rather that the phenomenon is relatively minor, since it doesn't show up in aggregate trade and investment statistics.

To sum up, neither studies on trade flows nor on FDI flows suggest that environmental regulations are an important factor in international location decisions. At the same time, the evidence from intra-US investment flows suggests that the exact location in a host country may at least partly be determined by regional and local variations in environmental regulations. In other words, once a host country has been chosen on the basis of more fundamental location advantages, such as labour costs, market size, corporate taxes, etc., environmental regulations may influence just where in the country the investment will be located.

D. Restraining factors that prevent the migration of polluting industries

If there are some cost savings to be made, what holds firms back from exploiting these cost differences by moving polluting plants offshore? As noted earlier, pollution-abatement costs are believed to account for between 1 and 5 per cent of production costs in the OECD. While the figures may suggest that the industries in the upper range of the span could be candidates for relocation, what matters is how much of these costs can actually be saved by moving offshore. This we do not know, since no data exists on pollution-abatement costs outside the United States. However, there seems to be a general assumption that environmental regulations are more or less on a par in developed countries, so the savings cannot be very high by moving polluting industries from, say, the United States to Canada. Yet, some three quarters of all FDI in the world is directed to developed countries. The real savings are then presumably to be found by moving polluting activities to developing countries: this is at least the working assumption in the literature. However, even in this case the cost savings may not be realized for a number of reasons.

First, the absence of formal regulations does not necessarily mean that industries can pollute freely. As discussed in Pargal and Wheeler (1996), survey evidence from developing countries suggests that local communities can sometimes exert effective pressure on firms to clean up their act even without the backing of formal regulations and laws. However, it depends very much on the socio-economic structure of the community in which the plant is located, including educational and income levels. For the case of Indonesia, they found a significant difference in pollution intensity between plants in the same industry located in communities with relatively high educational and income levels and plants located in communities with low educational and income levels. The same pattern was observed by Hartman et al. (1997) on the pollution intensity of pulp and paper plants in Bangladesh, India, Indonesia, and Thailand. These findings suggest that affluent communities with a relatively educated population can exert effective pressure on industries to clean up, while poorer and uneducated communities find it more difficult to make firms behave in an environmentally responsible way. This is just another illustration of the close link between poverty and environmental degradation.

Second, even if no regulations are imposed, whether formally or informally, it may still be in the interests of firms to make at least a minimum of effort to control pol-

82 Xing and Kolstad (1998) use economy-wide SO2 emissions as a proxy for environmental stringency for lack of more direct indexes. While not a perfect proxy, they point to the high correlation between SO2 emissions and five other major air pollutants (NOx, volatile organic compounds, CO, total suspended particulates, and lead).

lution so as to safeguard their reputation, to avoid consumer boycotts in environmentally conscious (export) markets, and to reduce the risk of legal liabilities, should a major environmental accident occur, such as the Bhopal accident in India.[83] In fact, many multinational firms seem to be heading towards a policy of standardized technologies for all their production plants in the world, including with respect to pollution abatement. According to the US International Trade Commission (1995), "much research indicates that multinational firms tend to replicate the technologies employed in their home markets when operating in developing countries. Indeed, the ability to duplicate technology in a number of countries is deemed central to the competitive strategies of most multinationals." (p. 24) Moreover, as noted by Schot and Fischer (1993), cited in Levy (1995), by the end of the 1980s, most large firms had adopted written environmental policy statements, with the majority claiming that they go beyond the minimum standards required by local laws and regulations. Finally, as argued by Palmer et al. (1995), multinational firms base their technology decisions not only on the current regulatory framework, but on what they expect in the future. Rather than retrofitting abatement equipment at great expense at a later date, it makes commercial sense to install state-of-the-art technologies at the time the investment is made. Indeed, some empirical evidence, as in Eskeland and Harrison (1997), suggests that foreign-owned plants in developing countries tend to be less polluting than indigenous plants in the same industry, although this is not always the case.

Another indication of increasing readiness to assume greater environmental responsibilities is the rapid adoption of voluntary environmental management standards (ISO 14000) promulgated by the International Organization for Standardization (ISO). According to an ISO press release, dated January 7, 1999, some 5,000 certificates had been awarded in 55 countries by the end of 1997, an increase of 300 per cent in one year. The first standards were published in mid-1996. The ISO 14000 standards provide companies, regardless of size or type, with a common framework for analyzing and managing the environmental impact of products and processes, including performance evaluations, life-cycle assessments, environmental labelling, and auditing. Although implementation of ISO 14000 is voluntary, certification is increasingly becoming a commercial necessity. Some of the advantages noted by Lally (1998) include reduced costs of liability insurance and bank loans, less regulatory oversight, and increased access to international markets. For example, certified firms often require their suppliers to be certified as well. She concludes that ISO 14000 certification is becoming "the gateway to the global market place".

Likewise, the drive to qualify for eco-labelling seals suggest that eco-labels, or, more generally, a green profile, can be a very valuable marketing asset that outweighs the additional costs of meeting higher environmental standards.[84] In other words, the additional cost can often be recouped in the marketplace.

In addition to the market pressure exerted by the growing number of environmentally conscious consumers, the financial community has its own reasons for ensuring that the firms they bankroll or own do not have a poor environmental profile. As shown by Lanoie et al. (1997) and Dasgupta et al. (1998), share prices fall significantly when unfavourable environmental news is published, such as oil spills or violations of emissions levels. And capital markets tend to react positively to favourable environmental coverage, such as reports of investments in clean technologies or public rewards for environmental excellence. Let us also recall the studies by Repetto (1995) and Cohen and Fenn (1997), which concluded that superior environmental performance does not come at the expense of reduced profitability. On the contrary, firms with a superior environmental record tend to outperform environmental laggards in the marketplace. This suggests that poor environmental performance is associated with poor management in general, and such problems should be relatively short-lived if financial markets function properly. Moreover, the growing number of ecological funds that invest exclusively in companies with a good environmental record will most likely have a significant effect on firms' environmental performance in the future. The reason is that the investment of these funds, when they become large enough to matter, will give an extra boost to the share prices of qualifying firms, which will not go unnoticed by other firms and their owners.

The general impression is thus that multinational firms cannot escape their environmental obligations by moving polluting plants offshore. The absence of formal regulations has been substituted at least partly by informal regulations. Moreover, market forces nowadays reward good environmental performance rather than cost savings at any price. True, it has not always been this way, but the tide has arguably turned in recent years. One reason is the efforts of non-governmental organizations that have made consumers sensitive to the environmental profile of both products and producers. When consumers care, producers care. A good environmental profile is perhaps more of an asset than a liability in the international marketplace, notwithstanding somewhat higher production costs.

E. A race-to-the-bottom, a race-to-the-top, or no race?[85]

While the above review does not suggest that environmental regulations are of primary importance for competitiveness or location decisions, there has nevertheless been a heightened concern among environmentalists that the removal of trade and investment barriers will undermine national and international efforts to halt and reverse

83 The accidental release of poisonous gas from a pesticide factory resulted in thousands of dead and hundreds of thousands of injured people. It was followed by years of lawsuits and an eventual settlement with the victims that cost Union Carbide $470 million directly and perhaps even more in lost international reputation and consumer confidence. (Source: www.earthbase.org.)

84 Eco-labelling (or environmental labelling) is a guide for consumers (including procurement divisions of firms and governments) to choose products and services that cause less damage to the environment than other products in the same category. To give an indication of the growing interest in eco-labelling accreditation, the coverage of the German Blue Angel Environmental Label has grown from 45 products in 1979 to 4,500 products in 1997, according to Robins and Roberts (1998).

85 This heading is borrowed from a survey by Swire (1996). Another excellent survey is that by Wilson (1996)

the process of environmental degradation. The ability of investors to locate their capital freely wherever the returns are the highest is said to produce a "race-to-the-bottom", by which is meant a vicious circle of gradually slipping environmental regulations driven by the competition between countries for international mobile investments.

We shall now take a closer look at the theoretical foundations of the race-to-the-bottom hypothesis. We shall also discuss the counter-hypothesis of a "race-to-the-top", which holds that governments, if anything, are more likely to bid up standards in a race to *prevent* the worst polluters from locating in their territory - the "not-in-my-backyard" (NIMBY) phenomenon. We shall then review the empirical evidence to determine whether if any of these theories are supported by data, or if they are just fictions that haunt the public debate with increasing frequency.

The intellectual origin of the race-to-the-bottom theory can be found in the literature on local public finance. The early concerns of this literature were not so much with the consequences for public policies of capital mobility but of household mobility. The key result is due to Tiebout (1956), who showed that the ability of people to "vote with their feet" leads to an efficient provision of public goods, that is, a level of public services that equals what people are ready to pay for. The intuition is straightforward. If local policies fall short of residents' expectations, some will move out, and if local policies are better than the national average, some will move in. This process will continue until public services and taxes have found an appropriate balance. That is, interjurisdictional competition puts pressure on local governments to deliver a level of services that people are ready to pay for, including appropriate levels of environmental protection. In other words, if there is a "race" in any direction, the race is towards efficiency in public policy.

While this insight is fundamental and important, it does not necessarily transfer to the case where the mobility is on the producer side instead of on the household side, which arguably is a more relevant portrayal of mobility at the international level. The question, then, is the following: if labour migration is restricted, whereas capital is free to move, how does that affect public policies in general and environmental policies in particular?

Perhaps the most influential paper on this subject is due to Oates and Schwab (1988). While it was written in the context of local competition for mobile industries, the same logic applies to international competition for mobile investments. Given a long list of assumptions, including that pollution generated in one jurisdiction does not spill over into another, Oates and Schwab show that policy competition for mobile capital results in an efficient outcome, in keeping with the Tiebout model of household mobility. Each community grants emissions permits up to the point where the benefit of capital inflows in terms of increased local income is just balanced by the harm caused to the local environment. In other words, if there is a "race" in any direction, the race is in the right direction, evaluated at the preferences of the average local resident (which may not, of course, suit each and every one in the community).

However, this result is sensitive to the underlying assumptions. One critical, but arguably reasonable assumption is that governments can use alternative instruments for attracting capital, for example, reduced tax rates. In fact, to the extent that there is a race-to-the-bottom in this model, the race is played out in capital taxes that are bid down. However, should capital taxes be downward inflexible, perhaps because of equity considerations, or because no alternative taxes are available to finance public expenditures, or because the federal government has introduced a downward cap on the tax rates (a policy that is currently under consideration by the European Union to halt tax competition between member countries), environmental standards could come into play as a tool for luring investments. Indeed, with this restriction on the model, environmental standards are bid down to socially inefficient levels, if not all the way down to rock bottom.[86]

Another factor that may induce a race-to-the-bottom is a biased political process. A race-to-the-bottom may emerge if the industrial lobby gets the upper hand over the green lobby. Or if the green lobby has the upper hand, environmental standards would be bid up to levels that are higher than what the median voter is willing to pay for.[87] In other words, the best assurance of a reasonable outcome for most people is a democratic process in which all interested parties have equal access to the political process.

A recent paper by Kim and Wilson (1997) expands further on the possibility of a race-to-the-bottom. They show that a race-to-the-bottom may emerge even in cases where governments have access to targeted instruments for attracting capital. The critical assumption in this case is that governments have to finance a certain amount of public expenditures. If capital taxes are reduced to lure investments, labour taxes may have to be raised instead, which in turn raises the cost of production. Given this policy dilemma, governments may be tempted to relax environmental standards instead. The authors show that the equilibrium level of environmental standards will be lower than if governments could commit themselves to abstain from reducing environmental standards for the purpose of attracting capital, for example, by signing a binding multilateral environmental agreement to that effect. That is, the competition for mobile capital boils down to a standard prisoners' dilemma with a sub-optimal outcome for everyone.

Kanbur et al. (1995) study the link between increased capital mobility and environmental policies. They show that economic integration enhances the competition for FDI, which in turn puts downward pressure on environmental standards.[88] What is more, if countries are of unequal size, it may be difficult to forge a cooperative agree-

86 Wilson (1996) finds a similar result, elaborating on a tax competition model by Huang (1992). He shows that if governments have no alternative instrument to tackle unemployment, such as reduced labour taxes or more flexible labour market rules, a race-to-the-bottom may emerge as a desperate act to induce investments and associated jobs for the unemployed.

87 See Fredriksson (1999) for a formal analysis.

88 A similar result was derived by Rauscher (1991).

ment to break out of the downward spiral. They show that harmonization of standards will leave smaller countries worse off, irrespective of the level at which standards are harmonized. At the same time, a cooperative solution entailing higher standards for larger (richer) countries than for smaller (poorer) ones would be beneficial for all parties. These findings give some indirect support to the proposition of "common but differential responsibilities", which holds that developing countries should not be asked to undertake the same commitments as developed countries so as to provide room for economic development. In fact, the moral of this model is that the quest for absolute harmonization among countries may backfire, in that developing countries may not sign proposed multilateral environmental agreements.

The models referred to so far assume that all kinds of investments are equally polluting. Arguably, this is not the case. The pollution intensity varies considerably between industries, from very polluting, such as energy-intensive primary processing, to virtually clean activities such as banks and financing. This insight raises an important question: Why would governments compete for polluting industries at all if they have the option of specializing in clean industries and importing goods that are polluting to produce. This issue is studied by Markusen et al. (1993, 1995). They show that if the two alternatives generate equal income, governments would always try to attract the clean industry. The only "rational" reason to host polluting industries is if the income gain is large enough to offset the pollution costs, or if the government for some reason has no alternative than to compete for polluting industries.

Another branch of the race-to-the-bottom literature has focused not so much on competition for FDI but on the scramble for world market shares in oligopolistic industries with supernormal profits. This literature is essentially a recast of the "strategic trade policy" literature,[89] whereby the "normal" strategic instruments, i.e., export and production subsidies, are exchanged for lax environmental standards, with little explanation of why governments would resort to inefficient policy tools when they have other more direct instruments at their disposal. In any event, as shown by Kennedy (1994), there are two critical forces that determine the outcome in these models: a "rent-shifting" effect and a "pollution-shifting" effect. What governments would ideally like to do is to capture as large a stake as possible of a lucrative industry with supernormal profits, without paying the price in terms of increased domestic pollution. However, this is not possible using environmental standards alone. On the contrary, while allowing the domestic industry to capture a larger share of the world market, lax environmental standards will also increase domestic pollution. That is, both profits and pollution are shifted from abroad to home at the same time. The authors show that if pollution is *purely* local, the pollution-shifting disincentives counterbalance the profit-shifting incentives, thereby deterring governments from manipulating environmental standards for strategic industrial purposes. However, if a large enough fraction of the pollution dissipates with wind and water outside a country's own territory, the rent-shifting incentives will start to dominate, and pollution taxes will then be bid down to socially inefficient levels in the scramble for international market shares. And the less localized (more globalized) the pollution, the lower the bottom that will be reached and the greater the risk to environmental quality through international policy competition.[90]

A synthesis of the theoretical findings is presented in Table 7. To sum up the findings, there is no doubt that a race-to-the-bottom is a theoretical possibility, and that trade and investment liberalization could exacerbate such tendencies. At the same time, race-to-the-bottom models are based on assumptions that need to be investigated closely. First, as shown by Oates and Schwab (1988), if governments have more direct instruments to attract FDI, there will be no race-to-the-bottom in environmental standards. Thus, to make the case for a race-to-the-bottom, we have to explain why governments do not have, or do not use, "normal" instruments for attracting FDI and supporting domestic firms in global competition. One reason could be that the first-best instruments are circumscribed. For example, export and production subsidies may fall foul of the WTO subsidy codes. Moreover, governments may not be able to lower taxes or raise subsidies for budgetary reasons. At the same time, a review of the investment incentives used in real life—including tax holidays, tax rebates, investment grants, interest rate subsidies, duty drawbacks, government contracts, designated land at symbolic prices, subsidized public services, etc.—suggests that governments' hands are not tied to such an extent that they need to resort to environmental laxity in order to attract investments.[91]

This is not to deny that governments sometimes do resort to non-transparent or opaque policy instruments, as any (trade) economist can bear witness. As noted by Guisinger (1986), "since investors usually wish to avoid alerting competitors or the public to any special treatment which they receive, corporations are likely to prefer an opaque jumble of incentives and disincentives to transparent forms of public subsidy. Governments, too, have reasons to prefer a variety of incentives to a single incentive. An array of incentives and disincentives can divert the attention of taxpayers, who are suspicious that the government is granting preferential tax treatment for corporations." (p. 86). As emphasized by Wilson (1996), a priority of future research should be better models of the 'political market failures' that may cause governments to bypass efficient tax and subsidy policies in favour of inefficient environmental policies.[92]

89 For an introduction to the strategic trade policy literature, see Krugman (1986).

90 One problem with the strategic trade policy argument is that the results are extremely sensitive to the underlying assumptions. The question of whether there will be a race-to-the-bottom or a race-to-the-top depends on whether firms compete in quantities or prices. For more on the sensitivity of these models, see, e.g., Barrett (1994) and Ulph (1997).

91 The use of investment incentives in the competition for FDI is discussed in detail in a note by the WTO Secretariat (1998b) for the working group on trade and investment.

92 In the political economy literature, the preference for opaque and non-transparent policy instruments is known as the "theory of optimal obfuscation". In essence, the less transparent the policy, the better for the government and the favoured clients. See Magee, Brock and Young (1989).

Table 7: Race-to-the-bottom, race-to-the-top, or race-to-efficiency?

Model assumptions	Race to the bottom	Race to the top	Race to efficiency
Household mobility and localized pollution			X
Capital mobility, localized pollution and:			
access to non-distortionary taxes to finance public spending			X
access only to distortionary policy instruments and:			
high unemployment	X		
polluting industries more profitable than clean industries	X		
polluting and clean industries equally profitable		X	
Capital mobility and transboundary/global pollution	X		
Capital mobility and:			
industrial capture of the political process	X		
green capture of the political process		X	

Having said that, when pollution problems are of a local nature, governments may rather be inclined to deter the location of polluting plants in their own backyards, leading to a race-to-the-top in environmental standards. In other words, countries that are able to pick and choose between industries, may set their policies with a view to deterring polluting industries in favour of clean industries, thereby indirectly pushing the pollution problems into the backyard of countries that are in a less privileged position.

This reasoning suggests that the race-to-the-bottom hypothesis may have been misread in the public debate. If some countries dissuade the location of polluting industries in their own backyard, or possibly even trying to induce existing firms to migrate, other more passive countries will end up with the polluting end of production. These other countries often receive derogatory epithets, such as "pollution havens", although they may have done nothing to attract these industries. It is possible, therefore, that any pollution haven phenomenon is an indirect result of a NIMBY attitude on the part of richer countries, and not a conscious effort by poorer countries to become the pollution and dumping grounds of the world.[93] Thus, when analyzing data, we must not forget the general equilibrium nature of the world economy, where any given flow may reflect either a policy change at the supplying end (raised environmental standards) or a policy change at the receiving end (reduced environmental standards). Without data to discriminate between the two alternatives, we should be cautious in our conclusions.

Also, in order to keep this debate into perspective, recall that environmental economics do not suggest that environmental standards should necessarily be harmonized across countries, at least not as far as standards regarding local environmental problems are concerned. Rather, as elaborated in Section II, different standards can be expected for different countries just as standards often vary within countries. The appropriate level of environmental protection depends on the ecological conditions, such as climate, soil composition, vegetation, past pollution, and other factors that affect the carrying capacity of the region. Moreover, even if the ecological conditions were identical, international variations in standards may be desirable in order to reflect differences in income and ability to pay for environmental quality. After all, the opportunity cost of environmental polices in terms of forgone income may differ considerably among poorer and richer countries, and neither would be served well by setting the standards at the average.

F. Empirical evidence of regulatory races and chills

The empirical side of the issue is clearly lagging behind the theoretical developments. Most of the evidence that is available at this stage is of an anecdotal nature. As far

93 Indeed, one could argue that the whole issue of exports of domestically prohibited goods provides some indirect support for this view. After all, developing countries have for many years sought the collaboration of developed countries to ensure that they do not become the dumping grounds of goods that are prohibited domestically in developed countries on environmental and health grounds, such as hazardous pesticides, insecticides and unsafe pharmaceuticals. The reason why they seek this collaboration is that they themselves do not always have the expertise to assess the health and environmental risks of the products that are on offer.

as the evidence of a race-to-the-bottom is concerned, Esty and Geradin (1998) cite a 1997 study by the Canadian Institute for Environmental Law and Policy, which reports that the government of Ontario has relaxed some environmental statutes in recent years so as to accommodate the commercial interests of forestry, mining, homebuilding, and agribusiness. They also point to recent amendments of German conservation laws, which are said to "give the economy a clear priority over the environment". They further cite evidence of a potential race-to-the-bottom between the United States and the European Union. In a speech given in July 1995, EU Environment Commissioner Ritt Bjeregaard criticized what she perceived as Republican-led efforts in the US Congress to relax environmental standards, which would send a "dangerous signal" to the rest of the world (implying that the European Union may have to follow suit to level the playing field). They also point to the strong lobby that is pressuring the European Union to revise its legislative framework in the areas of waste and biotechnology so as to move from legally binding to voluntary agreements. Finally, they point to the European Community's December 1995 decision to approve a proposal to ease restrictions on the use of genetically modified organisms.[94]

While this evidence shows that there are some instances of backtracking, it is questionable if they prove that the world has entered into a new phase of gradually slipping environmental standards in keeping with the race-to-the-bottom hypothesis. More evidence is needed.

The milder "regulatory chill" version of the theory has a more familiar ring. Industries often appeal to competitiveness concerns when lobbing against environmental regulations, and sometimes with some success. To reiterate some examples cited by Esty and Geradin (1998),[95] they point to the failure of major industrialized countries (EU, US, Japan, and Australia) to adopt energy taxes for addressing climate change. In 1992, the European Commission put forward a proposal for taxing carbon dioxide and the energy content of products. This proposal was conditioned on the EU's major trading partners acting in tandem. However, initiatives to that affect in United States, Australia and Japan were defeated by the industrial lobby (arguing that it would harm their competitiveness), and in the end, the proposal was withdrawn. Another example is the UK coating industry's 1995 victory over legislation that would have forced them to reduce their emissions of volatile organic compounds (VOCs), a major contributor to city smog and respiratory health problems. The argument was again that the industry would lose out in international competition if faced with such regulations. Finally, as a general observation, Esty and Geradin claim that "in almost every political debate over environmental policy in the United States, competitiveness concerns are cited as a reason not to move to tougher standards." (p. 20).

Thus, the question, to our mind, is not whether we have a "regulatory chill" effect or not, but rather how serious is the problem? It would be serious indeed if competitiveness concerns prevent environmental standards to be raised to appropriate levels, or if governments would feel compelled to build in protectionist elements in the regulations to "compensate" the industry for the alleged competitive effects. However, the competitiveness concerns could at least potentially be turned into a positive force if governments, that find it difficult to act individually for political reasons, instead seek cooperative solutions to environmental problems. The growing numbers of multilateral environmental agreements (currently some 216, according to UNEP (1996)) may be one indication in that direction. The lasting effect of the regulatory chill may then be more procedural than substantial. That is, the initiative may have to be shifted from the national to the supranational level, just as we saw a shift from the local to the federal level in the 1970s to overcome the foot-dragging at the local level.

On the other side of the coin, there is some evidence of isolated instances of a race-to-the-top or, more accurately, policies that seem to reflect a NIMBY attitude. In a sequence of papers, Levinson (1996b, 1996c and 1997b) examines state policies in the United States with regard to hazardous waste. He documents the upward drift in hazardous waste disposal taxes from the mid-1980s onwards, a trend that seems to accord with the race-to-the-top theory. He demonstrates that tax rates are interdependent, and that the policies are designed to encourage export of waste outside the state line and deter import. A case in point is the use of two-tiered dumping fees. For example, Alabama charges (or used to charge) $40 per ton for the disposal of waste generated by local firms, and $112 per ton for imported waste. Other states have "retaliatory" tax rates to ensure that local firms are not discriminated against when dumping waste out-of-state. South Carolina, for example, charges imported waste the higher of $34 per ton or the rate charged by the exporting state for waste imported from South Carolina. In terms of the welfare implications of the race-to-the-top, Levinson cautions us against jumping to the conclusion that the policy competition has been beneficial on the whole. While the growth in waste generation may have been tempered, which is good, the reluctance to accept out-of-state waste has also led to increased decentralization of waste disposal in the United States. This may be harmful to the extent that there are economies of scale or safety in hazardous waste disposal. Moreover, when charges are bid up to deterrent levels, industries may be tempted to store waste at the industrial site or dump it illegally somewhere with potentially graver environmental consequences than if it were disposed of on grounds selected and prepared for that purpose.

Apart from hazardous waste disposal, which seems to be the showcase of the NIMBY phenomenon, we have not found other supporting evidence. Specifically, we haven't seen any empirical evidence suggesting that governments purposely try to deter inflows of foreign polluting industries and encourage outflows of domestic polluting industries. Of course, the lack of studies does not mean that such tendencies can be ruled out. It may only signify that the empirical literature is lagging behind, because of the severe shortage of data. In short, the jury is still out.

94 See Esty and Geradin (1998), pp. 17 and 18, for details and references.

95 See page 19 to 21 of Esty and Geradin (1998) for details and references.

G. Concluding remarks

While competitiveness concerns seem to have been somewhat overstated in the debate, and while data do not seem to support the hypothesis that investments are fleeing developed countries for developing countries with more lax standards, environmental initiatives are nevertheless defeated from time to time because of competitiveness concerns. This finding suggests that at least *perceived* regulatory autonomy has diminished alongside the removal of trade and investment barriers, which in turn underscores the need to seek cooperative solutions to common environmental problems in the world.

V. The Relationship Between Trade, Economic Growth and the Environment

While economic growth and per capita income are perhaps the most commonly used indicators of human advances, environmentalists have long been concerned by the consequences of growth on the natural environment. Since the end of the 1960s, numerous reports have questioned the sustainability of economic growth and the West's consuming lifestyle. The most influential report was perhaps *The Limits to Growth*, authored by the Club of Rome,[96] which predicted that key natural resources—in particular non-renewable resources such as fossil fuels—would become increasingly scarce over time and eventually exhausted if economic growth as we know it were to continue. The same report also warned that the environment's carrying capacity would become overstrained by different pollutants, and possibly collapse, unless human activities were held at bay. In short, economic growth and environmental quality were viewed as being on a collision course in which one or other would eventually have to surrender.

Three decades later, some of the earlier warnings—in particular those related to fossil fuel exhaustion—have been found to be somewhat premature. The discovery of new deposits of fossil fuels, in combination with less energy-demanding technologies, has so far kept pace with demand, and the current issue is rather whether we can afford to burn all the reserves because of the potentially disastrous consequences for the global climate. Moreover, relatively simple abatement technologies, such as catalytic converters on cars and flue gas desulphurization equipment on smokestacks (scrubbers), have proven effective in bringing down air pollution in countries were such equipment has become mandatory.

Yet, even if largely exaggerated, the early warnings served as the necessary catalyst for governments to pass environmental legislation without which some of the gloomy predictions could have come true. Moreover, the adoption of adequate environmental standards is still lagging in many places, and it is still true that economic growth without the necessary precautions is not sustainable in the longer term. One reason why environmental protection is slow to be implemented in many countries is because of low incomes. Some countries may simply not be able to afford to set aside resources for pollution abatement, nor may they think that they should sacrifice their growth prospects to help solve global pollution problems that in large part have been caused by the consuming lifestyle of richer countries.

In any event, *if* poverty is at the core of the problem, economic growth will be part of the solution to the extent that it allows countries to shift gear from more immediate concerns to long run sustainability issues. Indeed, at least *some* empirical evidence suggests that pollution increases at the early stages of development but decreases after a certain income level has been reached, an observation that has come to be known as the environmental Kuznets curve (EKC).[97] An illustration is provided in Figure 7.

However, while some evidence is in favour of the EKC hypothesis, others are not. The evidence suggests that the EKC hypothesis may be valid for some types of environmental indicators, and for different reasons, but equally invalid for other important indicators (Barbier, 1997). Those indicators that appear to demonstrate some characteristics of an inverted U-shaped pollution path are certain types of local, primarily urban, air pollution and, to a lesser extent, some types of freshwater pollutants. In contrast, pollutants of a more global nature do not seem to accord with the EKC hypothesis, notably CO_2 emissions. In essence, countries seem more prone to act on pollutants that affect their own backyard than those that degrade the global environment, although there are also some encouraging developments in this regard, such as the reduction in ozone-depleting substances (CFCs) rendered possible by international cooperation under the Montreal Protocol.

Before reviewing the EKC literature in more depth, it is worth noting why trade is an issue in this context. The most direct reason is that trade is one cylinder that propels the engine of growth. Of course, what ultimately drives economic growth are investments in physical capital, human capital, and technology. The domestic savings rate is very important in this regard, since most investments are still financed out of domestic savings, notwithstanding increasing international investment flows. The huge differences in domestic savings rates, ranging from less than 10 per cent of GDP in some of the poorest countries in the world to more than 40 per cent in some East Asian countries, is a key factor in cross-country variations in growth rates and per capita incomes. The availability of investment funds and, no less important, the quality of the investments hinge, in turn, on the economic policies pursued by a country. A number of factors are important in this regard, including financial sector development to mobilize savings and allocate funds efficiently, the rule of law, macroeconomic and monetary stability, adequate infrastructure, an educated work-force, and an open trade regime.[98]

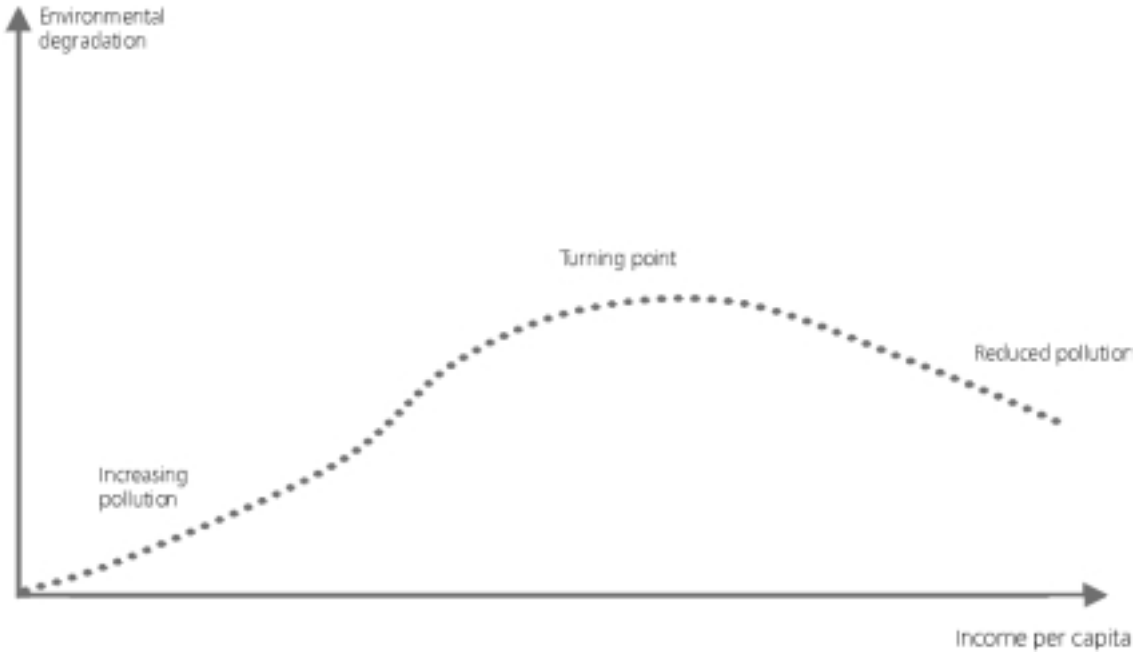
A far as the trade regime is concerned, the relationship with growth is mainly indirect and via two channels. First, trade barriers distort the price signals of an economy and thus also the allocation of scarce investment funds. Second, closed economies tend to fall behind in techno-

96 Meadows et al. (1972).

97 The hypothesis is named after Simon Kuznets (1955), who received the Nobel Prize for economics in 1971 for his work on the relationship between the level and inequality of incomes, which tend to follow an inverted U-shaped relationship. That is, income inequality tends to become worse as a country grows out of poverty, stabilizing at a middle-income level, and then gradually becoming more equal.

98 See Barro (1998) for a review of empirical growth studies.

Figure 7: The environmental Kuznets curve



logical development. Other things being equal, open economies tend to grow significantly faster than closed economies.[99]

Another reason why international trade figures prominently in this debate is that policy failures in the environmental arena are claimed to be caused or exacerbated by the pressure of international competition. Specifically, the ease with which firms can move nowadays when trade and investment barriers are at an all-time low is viewed as one important reason why governments may have become more reluctant to upgrade environmental standards. Growth driven by liberalization of the world economy may then defeat the EKC in that competitive pressure may prevent environmental standards from being upgraded to the extent necessary to turn the pollution path around. Indeed, growth *per se* does not reduce pollution; it requires that increased income be followed by tighter environmental standards.

A related argument is that economic integration may affect the shape and relevance of the EKC. It is at least conceivable that the turning point enjoyed by developed countries, if not yet in all environmental indicators, is partly a result of the migration of polluting industries to developing countries, although the evidence reported on earlier does not seem to support this assertion. In any event, if this is part of the explanation, it may become more difficult for the next generation of countries (higher-income developing countries) to pass the peak of the EKC, and harder still for the least-developed countries, since there will be no other countries left on which to pass the polluting industries. In short, the inverted U-shaped pollution path may not necessarily hold for lagging countries, nor for the world as a whole as far as global pollutants are concerned.

However, one can also make the opposite case. Developing countries may find it easier to pass the peak of the EKC because of new technologies that were not available at the time the developed countries were at the same stage of development. Thus, by facilitating the diffusion of technology, trade may rather lower the peak of the EKC.

As a final note of introduction, let us stress why the EKC hypothesis has generated such a fierce public debate. It is because of the profound policy implications were the hypothesis to be verified by data. It would turn previous warnings on their head. That is, improved environmental quality is contingent upon, or at least flows from, gains in per capita income, and not the other way round.[100] Policies would then be geared to securing economic growth, especially in developing countries, so as to speed up the

99 A detailed discussion of the linkages between trade and growth, including the empirical evidence, can be found in Chapter 4 of the WTO's 1998 Annual Report.

100 For example, Beckerman (1992) writes that "in the end the best—and probably the only—way to attain a decent environment in most countries is to become rich."

convergence of environmental standards, with a special emphasis on technology that preserves natural resources and reduces the pollution per unit of output.

A. Theoretical overview

A brief overview of the theory that underlies the EKC will help identify why it can assume the multiplicity of shapes that we observe in reality.

As mentioned before, the EKC draws its inspiration from the work of Simon Kuznets who observed that income inequality tend to become worse as a country grows out of poverty, stabilize at some middle income levels, and then gradually improve. The observation that environmental degradation may follow a similar income-dependent path was made by several economists at the beginning of the 1990s. Among them were Grossman and Krueger (1991), in a paper on the environmental consequences of NAFTA, Shafik and Bandyopadhyay (1992), in a background paper for the 1992 *World Development Report* on the link between development and the environment, and Panayotou (1993), in a paper for the International Labour Organization (ILO) on environmental degradation at different stages of economic development. The early studies were mainly empirical and it is only recently that attention has been given to the theoretical underpinnings of the EKC hypothesis.

There are several mechanisms that individually or in combination could generate an income-dependent path of pollution that eventually turns downward, including income-elastic demand for a clean environment, scale economies in pollution abatement, and structural economic changes inherent in the development process.

The most common explanation is perhaps that demand for environmental quality rises with income.[101] An inverted U-shaped pollution path is particularly likely to emerge if the demand for environmental quality rises faster with income than demand for other goods and services. This would be the case, for instance, if there exists a threshold income below which no resources are devoted to environmental protection. Indeed, countries living on, or close to, subsistence level may find it exceedingly difficult to set aside resources for environmental protection: day-to-day concerns, such as providing food and shelter, may simply predominate. Indeed, the very low saving rates in the least-developed countries, typically below 10 per cent of GDP and sometimes less than 5 per cent (which is not even enough to finance replacement investments of worn-out capital), suggest that such threshold effects may exist in reality.[102] When income grows, people presumably become both more able and more willing to sacrifice some consumption to protect the environment. Income-elastic demand for environmental quality is therefore one element that in itself or together with other supporting factors could generate a pollution path that eventually turns downward.

Evidence based on microeconomic studies suggests that demand for environmental quality indeed increases with income.[103] It should be stressed, however, that the willingness to pay for different categories of environmental amenities is not uniform, which is presumably one reason for the wide range of turning points that has been estimated for different categories of pollutants. Other things being equal, one would expect a turning point at lower incomes for pollutants that affect human health and quality of life in a very direct way, such as clean drinking water. The shape and form of the EKC may also reflect different possibilities of "defensive" action to escape pollution and associated health risks. For example, localized pollution, such as urban air pollution, can sometimes be escaped, at least by higher-income households, by moving to surrounding suburban communities. This may in turn reduce the political pressure from influential social groups to address the underlying problems.

If pollution harms production as well as people, the pollution trajectory will turn downward more rapidly.[104] A case in point is SO_2-emissions and associated acid rain which harm forestry, agriculture, and fishing. Failure to curb such emissions will harm growth itself, which is one reason why abatement measures will be introduced at relatively low income levels. (The turning point is estimated at between $4,000 and $5,000.)

The technology for pollution abatement is another factor that affects the EKC, as argued by Andreoni and Levinson (1998). To isolate the unique role of pollution-abatement technologies, they assume that the demand for environmental quality is independent of income. Given this assumption, it turns out that the EKC will take the classical inverted U-shape form *only if* abatement technologies exhibit *increasing* returns to scale, that is, if the unit cost of abatement falls with the scale of production. By contrast, with *decreasing* returns to scale, the EKC will be U-shaped, and with *constant* returns to scale, the EKC will be upward sloping over the whole income interval. In other words, for given preferences for environmental quality, the EKC hypothesis is more likely to hold sway if there are economies of scale in pollution abatement.

While no empirical evidence is put forward to support this argument, Andreoni and Levinson base their conclusions on standard microeconomic theory that scale economies in pollution abatement are likely just as for most other economic activities. Consider, for example, an abatement technology such as flue gas desulphurization equipment (scrubbers) on smokestacks to reduce SO_2 and NO_X emissions. This equipment may involve a substantial up-front investment, but may be rather inexpensive to operate once installed. The combination of high fixed costs and low operating costs suggests that the average cost per unit of abated pollution will fall as the volume of production rises. That is, there are economies of scale. If we accept this reasoning, it becomes obvious why pollution

101 See, e.g., Lopez (1994) and Selden and Song (1995).

102 Just to avoid misunderstanding on this point: it is not assumed that environmental quality is less appreciated by, or less important for, poor people. If anything, the contrary would apply, since their livelihood may depend more directly on nature's resources. The point is just that the costs in terms of forgone consumption may be prohibitively high for people living on subsistence incomes. For example, countries with a per capita income of less than $1,000 may find it considerably harder to set aside, say, 1-2 per cent of GDP for environmental protection than countries with a per capita income of $10,000 or more.

103 See, e.g., McConnell (1997) for a brief survey of microeconomic studies.

104 This point is elaborated by McConnell (1997).

may fall once a certain income level has been passed. The reason is that economic growth allows for more and more industries to reach the critical size at which the installation costs of abatement equipment can be borne with minimum impact on production costs and profits. After all, larger volumes allow fixed costs to be spread out more thinly.

Taking this reasoning a step further, we can establish a positive link between trade and pollution abatement. Since trade leads to increased specialization in the world, the size of the average production unit can be expected to increase, which in turn allows for economies of scale not just in production itself but also in pollution abatement. Put differently, without trade a country may never achieve the necessary scale economies in any production activity for it to be able to afford abatement equipment with high installation costs. Specialization and trade may therefore be part of a recipe to combat pollution.

Of course, each generation of abatement technologies has its own limitations. In other words, even if a given abatement technology exhibits increasing returns to scale, it may be necessary to install more sophisticated and presumably more costly equipment to reach an abatement target that goes beyond the limitations of the current technology. This opens up some interesting dynamic possibilities. As an economy grows out of poverty, pollution may first rise until it becomes profitable to install the most elementary and inexpensive types of abatement equipment, then fall as a result of these installations, then rise again as the scale of economic activity increases with growth until the next generation of abatement technologies becomes affordable, then fall again, and so on. Pollution may then follow a wave-like pattern in the race between increasing scales of economic activities and more advanced abatement technologies that become attainable with increasing scales. Indeed, the empirical review below will show, at least for some environmental indicators, that the EKC seems to follow an N-shaped pattern rather than the inverted U-shape. However, this may not be the end of the story. The next turn may be downward again, turning the N into an M, as the next generation of abatement equipment becomes attainable with higher production volumes and income.

Yet another factor that may explain the EKC is structural changes inherent in the development process.[105] Economic growth is a process of continuous transformation whereby certain sectors contract in relative terms (as a percentage of GDP), and possibly also in absolute terms, while others expand. A "stylized" development process may take place as follows.[106] Initially, the economy may be mainly agrarian. If the country is endowed with valuable natural resources, the next step may involve extraction of these resources combined with some basic processing. This first transitional stage is likely to be driven by demand from the world market and possibly facilitated by foreign investments (or, as in the past, colonization). The economy may then gradually move into basic manufacturing, such as textiles and clothing production on a more industrial scale, followed by more advanced manufacturing as experience and educational achievements increase. The "final" stage is presumably the post-industrialized society, with emphasis on high-technology production and services. Such a development process would gradually alter the pollution intensity and the composition of national output, so that some, but not all, environmental indicators would eventually improve.

The point is that what may appear as a relationship between income and pollution may have little to do with income *per se*, but may rather reflect underlying structural changes in the economy as the country grows richer. Take as an example the structural changes in the US economy between 1960 and 1994, as depicted in Figure 8.[107] Note the relative decline of primary production (agriculture and mining) and manufacturing as a share of GDP, counterbalanced by a relative increase in services, including public utilities and government services. These structural changes have presumably contributed to a drop in the overall pollution intensity of US output, although this assertion cannot be substantiated in figures. In contrast, other economies, such as the newly industrialized countries in Asia and Latin America, have moved in the opposite direction,[108] although this may only be a transient phenomenon. Indeed, Hettige et al. (1998) suggest that the manufacturing share of GDP typically rises until a country reaches middle-income status, peaking at some 25 per cent of GDP at a per capita income of about $5,000 to $6,000, to decline slowly thereafter to some 20 per cent of GDP at a per capita income of $20,000 or more.

Structural changes, in turn, are driven by many factors, including trade liberalization that induces specialization according to comparative advantages. As elaborated in Section III, trade liberalization changes the pattern of production in the world and so, indirectly, the pattern of pollution. From the point of view of an individual country, the local environment will benefit if expanding export sectors are less polluting on average than contracting import-competing sectors, and suffer otherwise.[109] And since one country's exportables are another country's importables, all countries cannot specialize in clean industries. International trade will therefore redistribute local pollution problems in the world from countries that have a comparative advantage in industries that are inherently less polluting to countries that have a comparative advantage in industries that are inherently more polluting. And even if an adverse composition effects may be counteracted by stricter environmental regulations induced by higher incomes, the technique effect is unlikely to neutralize both the scale and composition effects as argued by Copeland and Taylor (1994).

These arguments have some interesting implications. It is at least conceivable that the turning points that have

105 Panayotou (1993).

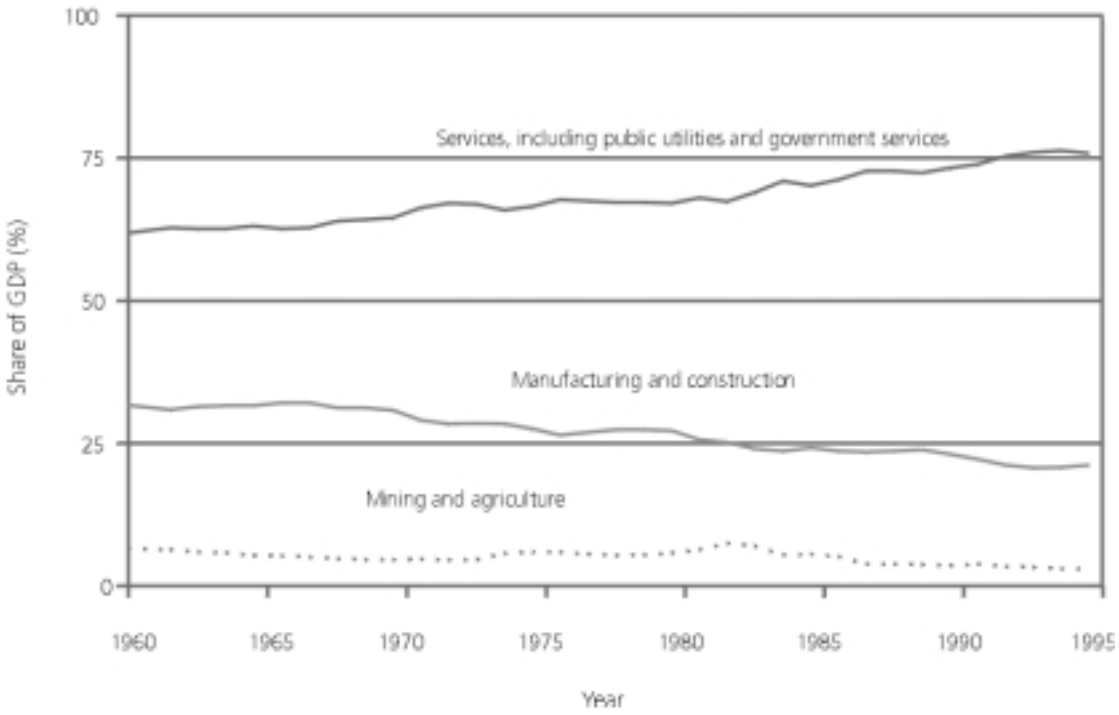
106 See, e.g., Syrquin (1989).

107 Data is taken from the Council of Economic Advisers, Economic Report of the President, February 1997.

108 Suri and Chapman (1998).

109 In practice, it may be difficult to evaluate if the environment actually benefited from the changing structure, since the composition of pollution also changes. What is the net benefit of, say, a 50 per cent reduction in SO2 emissions and a 10 per cent increase in toxic waste?

Figure 8: Structural changes in the US economy, 1960-1994



been enjoyed by developed countries, if not yet in all environmental indicators, are partly a result of the contraction of polluting industries. It is not certain that the next generation of higher-income developing countries can benefit from the same structural changes that would help reduce pollution, not to mention the least-developed countries, which may be stuck with the most polluting end of production. In short, the inverted U-shaped pollution path may not necessarily hold for lagging countries or, alternatively, the turning point may come at higher-income levels because of a more polluting composition of national output.[110] Likewise, the EKC may not hold for the world as a whole because the composition effect of individual countries cannot be replicated at the global level. Someone has to produce the polluting goods as long as they are in demand, although the production location may shift from time to time as comparative advantage changes.

On the other hand, developing countries may find it easier to pass the peak of the EKC because of new technologies that were not available at the time the developed countries were at the same stage of development. The question is then if available technology will be used, and new technologies developed to fill the current gaps, which in turn puts the focus on the ability of the political process to deliver environmental policies that are up to the job.

B. Is economic growth sufficient to induce environmental improvements?

This brings us to the question of whether the EKC is an automatic process or dependent on certain policy actions. It is probably both. Part of the solution may emerge spontaneously through normal market mechanisms. For example, if the willingness to pay a premium for goods produced in an environmentally responsible way increases with income, producers may modify their technologies accordingly to tap the green market niche. However, only the most laissez-faire economists would argue that the process towards sustainable development can be left to the market alone. Most would claim that government intervention is needed to complement and steer market forces in a sustainable direction.

A good starting point for a discussion on the policy dimension of the EKC is the insightful but technically difficult paper by Jones and Manuelli (1995). They consider an economy that has at its disposal a wide range of production technologies that differ according to both their production costs and their environmental impact. The government can influence the choice of techniques by appropriate taxes or regulations that steer firms towards more environmentally friendly methods. However, there are certain costs associated with such policies, including slower growth because of lower after-tax returns on investments. What determines the pollution path in this model are the political institutions for collective decision-making. They contrast the pollution path chosen by a

110 Results along these lines can be found in the simulations undertaken by William (1999).

"benevolent social planner" (through the imposition of environmental taxes or regulations) with recurrent direct voting on environmental policies, whereby the preferences of the median voter effectively determine the outcome.

Interestingly, the policies chosen by the benevolent social planner generate a standard inverted U-shaped EKC. When a country is poor, growth considerations take precedence over environmental concerns. However, as the economy grows out of poverty, pollution taxes or regulations are introduced at some stage and start to bend the pollution trajectory. At a sufficiently high level of income, pollution taxes or regulations have become so stringent that they encourage investments in sufficiently clean production technologies to start reducing the overall level of pollution. In short, an inverted U-shaped pollution path occurs naturally if environmental policies are determined by an enlightened government that at each point in time makes an optimal trade-off between production of goods and environmental quality, and where this trade-off changes with the income level because of income-elastic demand for environmental quality.[111]

Recurring voting on environmental taxes generates a somewhat different pollution path. In this case, the pollution may first rise as the economy grows out of poverty, then decrease over a middle-income range, and then start to rise again at high levels of income. That is, the pollution path replicates the N-shape that has been observed in some empirical studies. It is not entirely clear what exactly in the direct voting mechanism generates this peculiar shape.[112]

The more important point is that political institutions matter. The pollution path will not turn downward automatically with increasing income. It requires that the broader interests of the population be reflected in the political decision-making process, which is not always the case because democratic institutions are lacking and/or excessive weight is given to producers over consumers. To be more precise, if governments are not held accountable for their actions or inaction in recurrent elections, or if they give more weight to the interests of the industry over the concerns of the broader population, pollution should not be expected to turn downward just because income is growing. That would be an overly naïve position, which has unfortunately been peddled somewhat uncritically in the past. The key is that the victims of pollution must be able to access the political process on equal terms in order to allow for appropriate environmental policies to be developed. While this may not be the case everywhere today, the good news is that democracy tends to be a positive function of income, and perhaps this is the ultimate explanation for the EKC, or the lack thereof.

Indeed, global pollution that lies beyond the influence of any individual country, with the possible exception of the largest countries (emitters) in the world, does not fit the hypothesized inverted U-shape all that well. As shown by Copeland and Taylor (1995), in a dynamic multi-country trade model with sovereign decision-making over environmental policies, global pollution problems will not be solved by income growth alone. It requires multilateral cooperation, which may be difficult to forge because of free-riding incentives, although not impossible as shown by the growing number of multilateral environmental agreements (MEAs) in recent decades. In any event, weak institutions for collective decision-making at the international level are presumably one reason, or perhaps *the* reason, why the turning points of global pollutants are estimated to be much higher than for more localized pollution.

C. Empirical evidence

After this brief theoretical introduction to the EKC, we shall now turn to the empirical evidence.[113] As noted earlier, among the first to forward and test the EKC hypothesis were Grossman and Krueger (1991) in the heated debate preceding NAFTA.[114] This agreement was opposed by many environmental groups, who argued that free-trade access for Mexico to the large markets in the North would serve as a magnet for polluting industries seeking to avoid more stringent regulations across the border. This conjecture was partly based on the poor environmental performance of Mexican export processing zones, so-called *maquiladoras*, which already enjoyed free-trade status. Besides adding to the pollution problem in the US-Mexican border region, it was feared that NAFTA would harm the environment in the United States and Canada more broadly by putting downward pressure on environmental regulations to counteract the expected outflow of investments and jobs.

In their analysis of the environmental consequences of NAFTA, Grossman and Krueger argue that environmental standards should not be viewed as given once and for all, but rather that they tend to reflect the current living standard. As countries grow richer, standards can be expected to improve. In that case, the impetus of NAFTA would speed up the rise in environmental standards by allowing Mexico to grow out of poverty. The long-term environmental impact of NAFTA would thus be positive rather than negative as feared by environmental groups.

In order to test this hypothesis, subsequently known as the EKC, they made use of data collected by the World Health Organization (WHO), in collaboration with the United Nations Environmental Programme (UNEP), on the concentration of air pollutants in a cross-section of urban areas in different countries. They found that the concentration of SO_2 and dark matter tends to increase up to a per capita income level of around $4,000 to $5,000 and thereafter gradually decline. That is, they found an inverted U-shaped relationship between air pollution and per

111 This is not to say that the inverted U-shaped pollution paths that we sometimes observe in reality are socially optimal. While the basic shape may correspond, the turning point chosen by real world governments may differ considerably from the enlightened government of the model world.

112 It may have something to do with the somewhat special utility function. Jones and Manuelli assume that the disutility of pollution is only experienced in the second part of life. As shown by Eriksson and Persson (1998) in a similar model, if all generations suffer equally from pollution, the EKC attains the standard inverted U-shape.

113 See also the surveys by Stern (1998) and Barbier (1997).

114 Their 1991 discussion paper was subsequently published in a book: Grossman and Krueger (1993).

Table 8: Estimated turning points for the environmental Kuznets curve (US$)

Air Pollution						
	SO_2	SPM	NO_X	CO	CO_2	CFCs
Cole et al. (1997)	6'900	7'300	14'700	9'900		12'600
Grossman and Krueger (1993)	4'100					
Holtz-Ekin and Selden (1995)					35'400	
Moomaw and Unruh (1997)					12'800	
Panayotou (1995)	3'000	4'500	5'500			
Panayotou (1997)	5'000					
Selden and Song (1994)	10'700	9'600	21'800	19'100		
Shafik (1994)	3'700	3'300				
Water pollution						
	Faecal coliform	BOD	COD	Arsenic	Nitrates	
Cole et al. (1997)					15'600	
Grossman and Krueger (1995)	7'800	7'600	7'900	4'900		
Deforestation						
	Global	Latin America	Africa			
Antle and Heidebrink (1995)	2'000					
Cropper and Griffiths (1994)		5'400	4'800			
Panayotou (1995)	800					
Others						
	Heavy metals	Toxic intensity				
Hettige et al. (1992)		12'800				
Rock (1996)	10'800					

Source: This table is based on Table 2 in Barbier (1997).

capita income. Their results also hinted at the possibility that the emissions may eventually turn upwards again at around $12,000 to $15,000. Since Mexico's per capita income just so happened to be at the estimated downward turning point, the additional growth impetus from NAFTA could conceivably push Mexico over the top and initiate a process of improved environmental performance.

This thought-provoking, not to say controversial, study has been followed by a huge number of empirical studies that have partly confirmed, partly contradicted, and partly qualified Grossman and Krueger's findings. One lesson from this literature is that the existence of an eventual turning point depends almost entirely on the type of emission reviewed, making any generalizations about the EKC hypothesis problematic. The turning points range from a couple of thousand dollars per capita to incomes that are yet to be seen anywhere in the world, as shown in Table 8.

Another finding is that pollution, after declining for a while at middle-income levels, may turn upward at higher incomes. For example, Kaufmann et al. (1997) note that after passing the $12,500 per capita GDP mark, SO_2 emissions may once again start to increase. Based on this and other studies, including the original study by Grossman and Krueger, several observers have noted that the inverted-U shaped curve more accurately resembles an "N"-shape for many environmental indicators. However, as argued in the theoretical review, this may not be the

end of the story. The next turn in the pollution path may be downward again, so that the N becomes an M as the next generation of abatement technologies becomes attainable with increased production and higher incomes. Essentially, there is no knowing if this process will eventually converge and, in that case, if the ensuing emissions will be within the bounds of the carrying capacity of local and global ecosystems.

A third insight of the empirical EKC literature is that the relationship between different environmental indicators and income does not fit into one convenient shape. For example, Shafik and Bandyopadhyay (1992), testing the EKC hypothesis on 10 different environmental indicators—lack of clean water, lack of urban sanitation, ambient levels of suspended particulate matter, ambient sulphur oxides, annual rates of deforestation, dissolved oxygen in rivers, faecal coliform in rivers, municipal waste per capita, and CO_2 emissions—found almost as many shapes of the EKC as there were environmental indicators.[115] Lack of clean water and urban sanitation was found to decline uniformly with increasing income. By contrast, municipal-waste generation and CO_2 emissions seemed to increase more or less uniformly with income. Only air-quality indicators conformed to the "standard" inverted U-shaped hypothesis. The same picture emerges when putting together a large number of empirical EKC studies, as nicely summarized in Table 1 of Barbier (1997), reproduced below.

Two comments are warranted to avoid any confusion. First, note that the "CJM" study—Carson et al. (1997)—finds a consistent pattern that different air pollution indicators tend to decline uniformly with income, in contrast to other studies that find either an inverted U-shaped or N-shaped EKC. This may have a simple technical explanation. The study is based on data for a single country: the United States. Although per capita incomes vary considerably across the 50 states, the lack of observations in the income interval below $10,000 may not allow the authors to capture the upward-sloping segment of the EKC at lower incomes. That is, the "true" relationship may still be a standard inverted U-shape; it is just that all 50 states have already passed the peak of the EKC.

Second, in the study denoted "V" for Vincent (1997), all indicators suggest that pollution increases uniformly with income. Again, this may have a simple technical explanation. The study covers data from a single country: Malaysia. While incomes across the 13 states of the Malaysian federation differ significantly, the lack of observation in the interval above $10,000 may prejudge the estimated shape of the EKC. It cannot be ruled out that the pollution path will turn downward once Malaysia reaches higher incomes. That is, the "true" relationship may still be an inverted U-shape; it is just that none of the 13 states had, at the time covered by the study (1987-91), reached the peak of the EKC that might have allowed a downward curve to emerge in the statistical analysis.

These comments are not intended to discredit the single-country approach. The only purpose is to shed light on why these two studies stand out from the others that use "traditional" cross-country regressions allowing estimations on a broader income range.

Having said this, the general impression left by the summary statistics presented in the previous tables is that the empirical evidence in support of an inverted U-shaped pollution path is somewhat mixed. Those indicators that appear to demonstrate some characteristics of an inverted U-shaped pollution path are certain types of local, primarily urban, air and water pollution. In contrast, pollutants of a more global nature do not seem to accord with the neat EKC hypothesis, notably CO_2 emissions.

The question then arises as to why the EKC hypothesis holds for some environmental indicators but not for others, and also why the turning points differ so much, an issue already touched on in the review of the theoretical literature. Rather than delve deeper into the empirical validity of each argument, let us focus on empirical EKC studies that include information on the linkages to trade, which is, after all, of the most immediate concern to the trade and environment debate.

D. International trade and the EKC

As noted several times earlier, international specialization and trade change the composition of production in a more polluting way in some countries and in a cleaner way in others. That much is clearly understood and indisputable. What complicates the long-term analysis is that comparative advantages are not static or given once and for all, but dynamic and constantly evolving. This means that the pollution composition of national output will change over time, independently of changes in domestic and international trade barriers. For example, a country that puts a lot of resources into education will change its comparative advantages from unskilled to skilled production, which in turn will alter the pollution intensity and composition of the national output independently of changes in the trade regime that may occur at the same time. Likewise, a country that saves 40 per cent of its GDP, compared to the world average of some 20 per cent, will over time move from labour-intensive to capital-intensive production, with a corresponding shift in pollution levels. Since trade is only one aspect shaping the development process, it is difficult to isolate its specific impact on the ensuing pollution path.

Natural sciences have an advantage over social sciences in that they can study the isolated effects of one variable at a time, by holding everything else constant in a controlled laboratory environment. In contrast, economists have to look at historical data, often of doubtful quality, in order to try to isolate the effects of individual variables in a constantly evolving dynamic system. The closest we could come to a controlled experiment on how trade affects the evolution of pollution would be to compare two countries that start out with the same natural resource endowments, population per square kilometre and technological know-how, but where one country embarks on a self-sufficient or inward-oriented development strategy and the other on an outward-oriented development strategy. While it may be difficult to identify a suitable pair of countries that satisfies these requisites for in-depth his-

115 A similar catalogue of non-uniform results was found by Ekins (1997).

Table 9: The relationship between income and various environmental indicators

Environmental indicator	Inverted U-shape	Increasing	Decreasing	Constant	N-shape
Air pollution					
SO2	CRB, GK1, GK2, S, SS, P1, P2		CJM		
SPM	CRB, P1, S, SS	V	CJM, GK1		
Heavy particles			GK2		
Smoke	GK2				
Dark matter	GK1				
NOx	CRB, P1, SS		CJM		
CO	CRB, SS		CJM		
CO2	CRB, HS	S			MU
CFCs	CRB				
Greenhouse gases			CJM		
Air toxics			CJM		
VOC			CJM		
Water pollution					
Faecal coliform	GK2				S
BOD	GK2				
COD	GK2				
Total coliform					GK2
Lead			GK2		
Cadmium				GK2	
Arsenic	GK2				
Nitrates	CRB				
Ammoniacal nitrogen		V			
pH		V			
Deforestation					
Global	AH, P1				
Regional	CG				
Others					
Lack of clean water			S		
Lack of urban sanitation			S		
Municipal waste		CRB, S			
Heavy metals	R				
Toxic intensity	HLW				
Energy	CRB				
Traffic volumes	CRB				

Note: This table is based on Table 1 in Barbier (1997).

Key to studies: AH = Antle and Heidebrink (1995), CJM = Carson et al. (1997), CRB = Cole et al. (1997), CG = Cropper and Griffiths (1994), GK1 = Grossman and Krueger (1993), GK2 = Grossman and Krueger (1995), HLW = Hettige et al. (1192), HS = Holtz-Eakin and Selden (1995), MU = Moomaw and Unruh (1997), P1 = Panayotou (1995), P2 = Panayotou (1997), R = Rock (1996), S = Shafik (1994), SS = Selden and Song (1994), V = Vincent (1997).

torical case studies, certain candidates spring to mind, for example, North Korea and the Republic of Korea, East Germany and West Germany, or Eastern Europe and Western Europe more generally. Unfortunately, no such studies seem to be available. Rather, what most researchers have managed so far is to include an "openness" indicator in standard cross-country EKC regressions in order to say something about the impact on the pollution path of the trade policy stance followed by a country.

Earlier studies using this approach, including Grossman and Krueger (1991) and Shafik and Bandyopadhyay (1992), did not find much impact of the trade policy stance *per se*. The openness indicator was generally statistically insignificant, although not for all environmental indicators. For example, Grossman and Krueger found that the ambient SO_2 levels tend to be lower in cities located in countries conducting more trade, while the other air-quality indicators—suspended particle and dark matter pollution—did not seem to have any significant association with trade.

Another study by Lucas, Wheeler and Hettige (1992) found that the toxic (pollution) intensity of GDP had a positive correlation with Dollar's (1990) index of trade distortion.[116] Although this index does not say which sectors are protected, the fact that the toxic intensity of GDP is closely linked to the manufacturing share of GDP suggests that the Dollar's index is correlated with the protection of the manufacturing sector. The way we interpret this finding is not that protection *per se* is associated with a high degree of pollution, but rather that protection of the manufacturing sector is. This conjecture is also supported by the finding that the total emissions of toxic substances eventually decline with higher incomes, partly because the manufacturing share of GDP tends to decline as a country grows richer.

The study by Rock (1996) suggest that open economies are more polluting than closed economies, even when differences in the manufacturing share of GDP have been accounted for. That is, comparing countries with the same income level and the same manufacturing share of GDP, he finds that the more open economies tend to be more polluting. On the basis of this finding, the author argues that the recipe for economic development advocated by the World Bank and others (i.e., development based on trade and economic integration) has a high price in terms of environmental degradation, which even if it is not permanent, is at least transitional until developing countries have passed the peak of the EKC. Put another way, growth-promoting development strategies must include an environmental element to be sustainable in the long term.

Suri and Chapman (1998) analyze the impact of growth, international trade, and structural change on the turning point of the EKC for commercial energy consumption and so, indirectly, pollution related to energy consumption, including CO_2 emissions. They find that growing exports of manufactured goods are a key source of energy consumption in rapidly industrializing countries in East Asia and Latin America. The mirror image was observed in developed countries, where growing imports of manufactured goods has contributed to a slowing of the demand for energy. In short, trade has changed the composition of GDP in a more energy-intensive way in rapidly industrializing developing countries and in a less energy-intensive way in mature industrialized countries. Moreover, the authors argue that, as a result, the turning point of the EKC for energy has drifted upward in industrializing countries, and also in the world as a whole. The reason for this is that developing countries use less energy-efficient technologies, apply generally lower energy taxes and, in some cases, offer energy subsidies to spur industrialization.[117]

The study by Antweiler, Copeland, and Taylor (1998) is also relevant in this context, although they do not set out to estimate the EKC *per se*. Their objective is to quantify the underlying mechanism by which trade affects the environment, specifically, through the composition, scale and technique effects. The study focuses on the relationship between openness to trade and changes in ground level SO_2 concentration in a data set covering 44 countries from 1971 to 1996. They find that a 1 per cent increase in the share of trade in GDP reduces SO_2 concentration by some 0.7 per cent for the average country. At the same time, countries that are induced to specialize in SO_2-intensive production may still see higher emissions. Again, trade changes the location of production and thus indirectly also the distribution of pollution in the world.

In summary, empirical evidence suggests that the composition effect of trade can influence the shape and relevance of the EKC. Structural changes in the global economy in the last decades may have shifted some manufacturing industries from developed countries into rapidly industrializing developing countries, and this in turn has influenced the pollution path of both groups of countries.[118] Since traditional manufacturing industries are generally more polluting than high-technology and services production, the structural changes may have helped developed countries to pass the peak of the EKC, if not yet in all environmental indicators. At the same time, the upward-sloping segment of the EKC for industrializing developing countries may have become steeper and the peak possibly higher because of a more polluting composition of their national output. In short, while trade spurs economic growth, thereby possibly shortening the time before appropriate environmental policies are introduced, the composition effect of trade will make the transition over the EKC peak easier for some countries and more difficult for others.

Having said this, the composition effect should perhaps not be exaggerated. For example, a decomposition undertaken by de Bruyn (1997) of the reductions in industrial SO_2 emissions in West Germany and the Nether-

116 The Dollar's index is based on a comparison between domestic prices and world market prices. The larger the divergence of domestic and world market prices, the more distorted the domestic price structure. This index is supposed to capture the influence of trade barriers, although divergence of domestic prices could be attributed to many other factors, including non-uniform domestic taxes, varying degrees of competition, and so on.

117 In fact, a phase-out of energy subsidies in both developed and developing countries has been identified as a key factor in a successful global strategy for reducing energy consumption and associated environmental problems, including climate change. On this point, see, e.g. Anderson and McKibbin (1997).

118 For a recent descriptive study on the pollution patterns during the industrial transitions, see Auty (1997).

Table 10: Decomposition of commercial SO_2 emissions between 1980 and 1990

	West Germany	Netherlands
GDP	26.1%	28.2%
SO_2 emissions	- 73.6%	- 58.7%
Emissions/output ratio	- 79.0%	- 67.7%
technological change	- 74.9%	- 73.5%
structural change (the composition effect)	- 4.1%	5.7%

Source: This table is based on Table 1, de Bruyn (1997).

lands between 1980 and 1990 found that technological change driven by higher energy taxes and stricter regulations is the key to improved environmental performance. Structural changes in the composition of national output added some further reductions in air pollution in Germany and subtracted some potential reductions in the Netherlands (Table 10). Thus, when the dust has settled, environmental degradation is perhaps not so much about trade, but rather about misplaced economic incentives that allow producers and consumers to pollute without bearing the full social costs of their actions. These policy deficiencies are presumably not unique to open economies, but generic problems of the political decision-making process. At the same time, the globalization of the world economy may have reduced the regulatory autonomy of countries, thereby making it more difficult to upgrade environmental standards unless as part of a concerted effort among nations.

E. Concluding remarks

To conclude our discussion on the EKC, let us start by emphasizing that nothing in the relevant literature suggests that the pollution trajectory will turn downward with increasing income by compelling necessity. If the economic incentives facing producers and consumers do not change with higher incomes, pollution will continue to rise unchecked alongside the increasing scale of economic activity. Indeed, Grossman and Krueger, who set the stage for this literature, would be the first to reject simplistic arguments along the lines that income growth will in and by itself take care of the pollution problems of the world. As they note in their 1995 paper, "the strongest link between income and pollution is via an induced policy response... Richer countries, which tend to have relatively cleaner urban air and relatively cleaner river basins, also have relatively more stringent environmental standards and stricter enforcement of their environmental laws than middle-income and poorer countries." (p. 372)

In other words, income growth, while perhaps a necessary condition for changing the focus from more immediate economic and social concerns to longer-term sustainability issues, is not sufficient to reverse environmental degradation. Environmental policies must follow suit. The importance of democratic institutions cannot be underestimated in this regard. Governments that are not held accountable for their actions will not necessarily deliver the necessary modifications to environmental policies to turn the pollution path around. Torras and Boyce (1998) make the case convincingly. Comparing countries with similar per capita incomes, they show that pollution levels tend to be significantly higher in countries with a skewed income distribution, a high level of illiteracy, and few political and civil liberties. Moreover, the inclusion of these political-access variables in otherwise standard EKC regressions considerably weakens the relationship between per capita income and environmental quality, although the linkage does not disappear completely. This suggests that the EKC relationship is not so much dependent on income levels *per se* as on institutional and democratic reforms, which tend to go hand in hand with increased income and which are necessary for allowing ordinary citizens to articulate their preferences for environmental quality and influence the political decision-making process on equal terms.[119]

This conclusion is not limited just to the domestic but also to the international sphere. Remember, one of the disturbing conclusions of the empirical literature is that the turning points of global environmental problems, such as global warming driven by CO_2 emissions and other greenhouse gases, are estimated at considerably higher incomes than more localized problems. One interpretation of this is that people do not care much about global warming and climate change. They would rather accept the consequences than the costs of curbing the emissions. An alternative explanation for the political foot-dragging that has gone on until very recently (the Kyoto Protocol) is the strong free-riding incentive in combination with weak institutions for collective decision-making at the international level, including inadequate enforcement mechanisms. Indeed, one reason why the WTO seems to have become the focal point for environmental disputes—in spite of the fact that environmental issues, with the exception of trade-related aspects, are by and large outside its mandate—is presumably because the WTO, unlike many other international institutions, has an integrated adjudication mechanism backed by trade sanctions as the ultimate enforcement tool.

119 A similar conclusion was reached by Panayotou (1997).

Having said this, it should be noted that global warming and depletion of the ozone layer are rather recent public concerns. It is at least conceivable, not to say plausible, that the varying turning points that have been estimated for different kinds of pollutants have a tendency to fall within the income range of the leading countries at the time the specific problems became an issue of intense public debate. For example, there may be nothing either special or natural about a turning point for CFCs at $12,000 to $18,000; it just happened to be the income range of the leading countries (which have also assumed the fastest phase-out commitments) at the time the Montreal Protocol was signed in 1987. Accordingly, although we find estimates of a turning point for CO_2 emissions of up to several hundred thousand dollars in per capita income,[120] reflecting the almost linear historical relationship between consumption of energy and income, the fact that global warming has now come to the forefront of public attention will presumably mean that emissions will be curbed at an earlier date, although this requires that countries go from words to action and honour the commitments made under the Kyoto Protocol. It also requires that the free-riding problem can be controlled by encouraging commitments also from developing countries, taking into account their justifiable development aspirations and the fact that developed countries have contributed the lion's share of the increasing concentration of greenhouse gases in the atmosphere during this century. In the end, the EKC may not have a "natural" turning point: it will turn whenever the political conditions are ripe for delivering the policies required to turn environmental degradation around.

The other point we would like to emphasize is that the EKC literature has so far focused mainly on the turning points for emissions, which can be somewhat misleading. The problem with this approach is that certain emissions, such as heavy metals and other inert toxic compounds that nature does not break down naturally, accumulate in ecological systems. Therefore, even if there is a turning point for emissions at some income level or the other, the cumulated harm inflicted during the transition up to the peak of the EKC may exceed the ecosystem's carrying capacity and may even be irreparable. The precautionary principle then advises us to take action well before the estimated limits of the ecosystems' carrying capacity have been reached, especially since the damage may occur abruptly and unexpectedly.[121]

A final point is that not all kinds of growth are equally benign for the environment. Economic growth requiring ever more inputs of natural resources is obviously not as harmless as economic growth driven by technological progress that saves inputs and reduces the emissions per unit of output. That kind of growth will not necessarily emerge spontaneously, but may require economic incentives that steer development in a sustainable direction. Trade could play a positive role in this process by facilitating the diffusion of environmentally friendly technology in the world.

Let us end this section with the authoritative conclusions of Arrow et al. (1995): "Economic growth is not a panacea for environmental quality; indeed, it is not even the main issue. What matters is the content of growth—the composition of inputs (including environmental resources) and outputs (including waste products). This content is determined by, among other things, the economic institutions within which human activities are conducted. These institutions need to be designed so that they provide the right incentives for protecting the resilience of ecological systems. Such measures will not only promote greater efficiency in the allocation of environmental resources at all income levels, but they would also assure a sustainable scale of economic activity within the ecological life-support system. Protecting the capacity of ecological systems to sustain welfare is of as much of importance to poor countries as it is to those that are rich."

120 Suri and Chapman (1998).

121 See Arrow et al. (1995) for a greater elaboration of this point.

VI. Concluding Remarks

One of the greatest challenges facing mankind at the inception of the 21st century is how to accommodate a growing population and material aspirations in developed and developing countries without compromising the natural environment. This challenge is compounded by the vast difference in living standards in the world, and hence differences in immediate policy priorities. It is also compounded by the fact that many environmental problems are transboundary or global in nature, and hence beyond the control of any individual nation.

The frustration in some quarters with the slowness of the political process in responding to these challenges has partly been blamed on the multilateral trading system. Part of the argument is that the legal provisions of the WTO circumscribe the tools available for environmental policy making, including trade measures to encourage participation in and enforcement of multilateral environmental agreements. The other part of the argument is that international trade, by increasing the mobility of industries, undermines the regulatory power of individual nations. Both of these arguments deserve to be taken seriously, although this study shows why trade measures are nearly always a poor policy response to environmental degradation.

The removal of economic borders imposes new demands for cooperation among governments on environmental issues. At the same time, countries would be interdependent in an ecological sense even if they did *not* trade. Ecological systems do not begin and end at the border, nor does pollution traveling with wind and water. The point is, rather, that the removal of economic borders and the associated increase in mobility of industries, has made cooperation more urgent by reducing the regulatory automony of individual nations The perceived costs of acting alone in terms of lost investments and jobs often take the steam out of new regulatory initiatives.

But this need for cooperation goes far beyond what the WTO is capable of delivering by itself, especially since environmental problems and international trade are only indirectly linked. At the same time, the cooperative model of the WTO, based on legal rights and obligations, could potentially serve as a model for more structured environmental cooperation among nations. Today, international cooperation on the environment finds expression through a multitude of organizations and conventions, not always coherently linked together. Of course, to find the appropriate forms for a new global architecture of environmental cooperation may take some time, and will have to account for a broad spectrum of interests and opinions, including inputs from civil society.

Meanwhile, even with its current mandate, the WTO can do a few important things for the environment. The most obvious contribution would be to address the remaining trade barriers on environmentally-friendly production technologies and environmental services in order to reduce the cost of investing in clean production technologies and environmental management systems. Another potential contribution would be to seek reductions in subsidies that harm the environment, including energy, agricultural, and fishing subsidies.